EXPLORING BRAIN-BASED INSTRUCTIONAL PRACTICES IN SECONDARY EDUCATION CLASSES

by

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ABSTRACT

Research on how the brain perceives, processes, stores, and retrieves information is important to guide pedagogy, yet many schools continue to promote practices that are inconsistent with practices suggested by brain research. Brain-based teaching practices promote a more holistic approach to teaching that acknowledges the interconnectedness of the brain and how it naturally learns.

In order to explore brain-based teaching practices, this study focused on a high school (grades 9-12) in southwestern Idaho to determine whether teachers' perceptions of their use of brain-based teaching strategies are consistent with the strategies they demonstrate in the classroom. Data included two original instruments: a 12-item self-assessment survey to measure teachers' perceptions, and a 12-item rubric to serve as a checklist to measure teachers' behaviors during a one hour classroom observation. Both instruments were aligned with one another and based on Caine, Caine, McClintic, and Klimek (2005) 12 brain/mind principles.

Teachers, who volunteered for the study, filled out a 12-item survey. The scores on the survey were compared to the scores on the rubric to determine the strongest overall competence with regard to brain-based teaching strategies and how it related to the teachers' claims of using brain-based strategies. In addition, data included field notes,

a 20-30 minute in-depth, open-ended interview with the teachers, and classroom artifacts, such as assignments, assessments, and students' writings, to provide evidence of brain-based teaching strategies and to clarify instructional procedures.

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CHAPTER ONE: INTRODUCTION

This study examined whether high school teachers' perceptions of their use of brain-based teaching strategies were consistent with the strategies they demonstrated in the classroom. Brain-based instruction refers to teaching strategies that are used to enhance the student's ability to process and integrate information in meaningful ways. The brain constantly seeks to impose order on incoming stimuli and to generate models that lead to adaptive behavior and useful predictions (Reilly, 1989). Curriculum planning that integrates a more complex "whole systems approach" is most effective for how the brain naturally learns. Although the human brain is a complex organ and our understanding is meager (Greenleaf, 1999), we do know that the brain is interconnected and not neatly divided into three units where survival learning is in the lower brain, emotions are in the mid-brain, and higher order thinking is in the upper brain (Jensen, 1998). Academics that embrace a more holistic approach to learning, that is, stimulating the whole brain, provide students a multiplicity of strategies to help them discover relationships, group related concepts and ideas, and make connections to their lives, in order to increase comprehension and recall (Caine, Caine, McClintic & Klimek, 2005).

Historically, education has concentrated on the development of the rational or left-brain powers, while paying little attention to the affective or right-brain development (Warchock, 1981). Hannaford (1995) writes:

> Logic, sequence, computation, categorization, verbal skills are all highly prized abilities in school. Intuition, emotion, vision, humor, rhythmic movement, image

> formation, and other gestalt brain capacities are not practiced, tested or particularly valued at school. It is only in the real world, outside of the classroom, where success depends upon entrepreneurship, imagination and insight that we begin to appreciate the importance of the gestalt brain. (p. 178)

Sanders and Sanders (1984) contend that pedagogy that embraces hemispheric interaction is critical if students are to evolve into independent thinkers, capable of negotiating the known with the unknown in their search for deeper meanings and connections. Endeavoring to promote a more balanced, holistic approach to learning involves acknowledging the unique specialties of each hemisphere—the left, which for most people, is logical, analytical, verbal and sequential, while the right is intuitive, conceptual, nonverbal, and pattern-seeking. Incorporating both the right and left hemispheres in curriculum planning allows for greater depth of understanding as the student explores the realm of possibilities in finding solutions.

> If we are to avoid producing an entire generation of "cognitive cripples" (people who depend solely upon the "left brain" or upon thinking of others), we must introduce creative methods as well as methods to enhance creativity within the classroom. We must teach our students how to think for themselves. (p. 24)

Limiting a student's experience to more left hemisphere activities, (such as, repeated instruction geared to facts and details, sequential ordering, lecture/discussions, drill and practice and textbook readings) results in a learning environment that is inconsistent with how people naturally learn, that is, through a process of exploration where a child changes and modifies what he already knows to gain new knowledge. This constructivist view of how the brain learns acknowledges that new and higher-level neural structures grow from or connect to structures already there. “Learner-centered environments attempt to help students make connections between their previous knowledge and their current academic tasks” (Bransford, Brown, & Cocking, 2000, p. xvi).

How then does narrowly defined curriculum that focuses upon the memorization and acquisition of disconnected sets of facts and skills affect students’ processing skills? Smilkstein (2003) maintains that human beings’ innate learning process is stifled by “dumbing down” curriculum. By limiting the parameters of education to a prescribed set of guidelines and expected outcomes, students are robbed of the opportunities to construct their own meanings through challenging activities that stimulate the brain’s natural ability of pattern-seeking, problem-solving, logical thinking, and creativity. By imposing an unnatural setting where information is filtered through an objective lens, learning becomes something static, limited and permanent, rather than open-ended, evolving and dynamic. Students are programmed to enact behavior patterns that promote success in school, but are ineffective in the real world where creative thinking and problem solving are necessary to survive. Students who do not adapt well to this regiment, Smilkstein suggests, appear unable to learn, not wanting to learn, apathetic or rebellious. However, when students are given the opportunity to experience activities and environments that are compatible with the brain’s natural learning process to be critical and creative thinkers, students learn naturally, successfully and with motivation (p. 29).

This study used teacher surveys, classroom observations, classroom artifacts (i.e., assignments, projects, students' writing) and teachers' interviews, to determine whether teachers' perceptions of what they do in the classroom are consistent with strategies they use in the classroom that demonstrate brain-based techniques.

Research Question

Are teachers' perceptions of brain-based strategies used in the classroom consistent with what is demonstrated in the classroom?

Theoretical Framework

As a teacher with a master's degree in secondary reading, it is frustrating to witness how some students, despite their efforts and mine, make little or no progress in reading comprehension and fluency. In a search for answers, I discovered a program that helps at-risk students process information more efficiently using a whole brain approach to learning that incorporates exercises to change how the brain perceives and processes information, including that which affects attitude, thinking, physical movement and learning.

The program is based on scientific evidence revealed through imaging technology that through stimulation in the environment the brain can physically change (Kotulak, 1997). Through enriched experiences, neural synapses, the junctions in the brain through which information passes, can sprout new branches and connections which continually change, reprogramming the brain to improve learning (LeDoux, 2002). By using repetitive exercises to re-pattern the neurological systems, the program helps the student acknowledge his own difficulties with learning and allows time and space to repair those areas of weakness.

Evaluating their own learning helps develop students' motivation, confidence and capacity to become independent learners. "Learners are most successful if they are mindful of themselves as learners and thinkers" (Bransford et al., 2000, p. xiv). However, unlike this learning program, where processing and self-awareness are emphasized, schools provide little time or space for meaningful connections and associations. "Children who naturally view the world as 'process' not 'product', need an environment for creativity, not just orderly prescriptions" (Sanders & Sanders, 1984, p. 33). Yet, schools require that the student adhere to a regimented system where the product is more highly prized than the process.

Although, it may be necessary to show concrete evidence of academic achievement through standardized test scores, the imbalance that exists between the process and the product may be adversely affecting our children's brains and ability to adapt and think in an ever-evolving world. "Educators who insist on singular approaches and the 'right answer' are ignoring what's kept our species around for centuries" (Jensen, 1998, p. 16). Survival requires that a human being rely upon a natural ability to merge patterns and logic into a problem solving process. "Although the brain innately knows how to learn, the knowledge, skills, or concepts the brain acquires by means of its innate learning process depends on the learner's experience and environment" (Smilkstein, 2003, p. 29).

By ignoring the learner's experiences and homogenizing education into neatly controlled portions, students become passive consumers repeating memorized information, while no longer participating in the construction of their own understandings. Education becomes an act of depositing (as in banks) from those who know to those who don't know anything (Freire, 1970).

Dewey (1933) wrote that educational practices which emphasize mechanical drills and recitations, may give results more quickly, but seriously impair the student's ability to think and understand. "This method reduces the 'training' of human beings to the level of animal training" (p. 63). In order to help students become active participants in their own learning process, experiences that promote curiosity are essential. Michael Gelb (1998) writes:

> Although we all started life with a da Vinci-like insatiable curiosity, most of us learned, once we got to school, that answers were more important than questions. In most cases, schooling does not develop curiosity, delight in ambiguity, and question-asking skills. (p. 65)

Background for the Study

Research on how the brain perceives, processes, stores and retrieves information is important to guide pedagogy, yet many schools continue to promote practices that are counterintuitive to the brain and how the brain learns. Too often, curriculum is taught in isolation with little effort to help the student make meaningful connections across the curriculum. Learning is interpreted as knowing fragmented pieces of information that students regurgitate on tests. Without making connections to a larger whole, very little, if any information is being stored. “Too many students never comprehend the ‘big picture’ of how the content they are learning fits into the larger scheme of things” (Wolfe, 2001, p. 48).

A curriculum that engages both sides of the brain simultaneously emphasizes both content (which for most people involves the left hemisphere) and context (the specialty of the right hemisphere). Curriculum taught in isolation of context fails to help the student make meaningful connections and, thus, adversely affects a student’s knowledge base and preparation for life.

Rapid communication between the two sides of the brain is particularly important in problem solving and creativity. Like in math, for instance, research suggests that persons who are math-gifted, process information more efficiently between the two hemispheres during problem solving (Davis, 2004, cited in Corbin, 2008). Given that math is a whole brain activity, students need to learn not only the procedures, but also understand the underlying concepts in order to master specific math skills. Without developing a foundation, students who are enrolled in algebra classes, for example, may not remember how to multiply and divide fractions. Students need time to connect the information, rather than memorize procedures that enable them to simply “get by” in lower level math classes.

Clearly, conceptualization, the brain’s ability to connect information into meaningful patterns, is less emphasized in a curriculum that focuses more on “how” a procedure is used, rather than “why” a procedure is used. When students rely only on procedural knowledge without conceptual knowledge, they may apply procedures incorrectly as well as experience difficulties when presented with different variations of a similar problem.

In today's world of short-term fixes and "No Child Left Behind", the student is expected to demonstrate proficiency with prescribed "procedures" in order to pass the ISAT (Idaho Standard Achievement Test). Thus, any pursuit to increase conceptual understanding finds itself in conflict with the tendency to 'teach and learn to the test'. In this sort of environment students lack a foundation of reasoning rooted in what John Dewey (1933) terms as "reflective thinking", which consists of "active, persistent, and careful consideration of any belief or supposed form of knowledge" (p. 9). Though more time consuming, "reflective thinking" involves an orderly sequencing of information that connects the learner's prior experience with new ideas to promote deeper understanding. Without such a foundation, it could be argued that students believe the essence of algebra, for example, is memorizing rules and procedures (Woodbury, 2000), when in fact, it is aiding the students understanding of more complex issues. "Processes and procedures expedite the solution process, but knowing which procedure and how to apply it is impossible without a working knowledge of the concepts that created them" (Jack, 2006, p. 7).

Thus, it seems imperative that pedagogy honor the learner's prior experiences in order to build a solid foundation for future learning experiences. "Perhaps an increased understanding of the cerebral hemispheres will assist us in designing curriculum and pedagogy that results not only in increased student understanding of information taught, but also in increased ability to use the information appropriately" (Wolfe, 2001, p. 48).

Importance of the Study

In an era of accountability, education has been limited to a structure that confines a student's learning to a prescribed set of goals and objectives assessed by a multiple choice standardized test. Although testing is necessary to assess learning, it cannot be the primary purpose of education. Rather, education that promotes and develops the brain's natural ability to learn focuses on pedagogy and curriculum that facilitates the growing and connecting of students' brain structures for more efficient processing. In such an atmosphere, a more holistic approach to teaching emerges where pedagogy acknowledges the interconnectedness of the brain and how it naturally learns.

Studies provided in Chapter II of the Literature Review, show that brain-compatible education, that which bases its teaching strategies on sound principles derived from brain research, leads to improved academic performance. In order to explore brain-based practices in a high school, this study determined the consistency of teachers' perceptions of using brain-based teaching strategies with behaviors demonstrated in the classroom.

Assumptions

In this study, the following assumptions were made:

1. Classroom practices that involve both the teacher and the students were not compromised by the researcher's observations.
2. Participants answered the survey and interview questions honestly.

CHAPTER TWO: REVIEW OF THE LITERATURE

Over the past decade there has been a surge of information revealed through brain imaging techniques to suggest that the brain is a highly complex, interrelated organ that is dynamic, that is, capable of growing new neural pathways when stimulated by experiences. Although this knowledge could help guide educational practices, the bridge between neuroscience and education remains unsteady. Neuroscience has yet to make significant progress in its research findings to confirm how the brain learns. However, through the integration of cognitive science, learning sciences and other disciplines related to human functioning and behavior, possible frameworks for learning and instruction could be provided (Bruer, 1997). The literature reviewed for this study emphasizes a constructivist approach to pedagogical practices, that is, one which focuses on the learner's innate ability to make personal connections and construct meaning.

This chapter is divided into five parts. Part I will examine current theory on the brain and how it functions. Part II will explore the implications based on brain theory for classroom practices. Part III will look at studies conducted on brain-compatible strategies, those strategies advanced by the current brain research, and the impact on student learning. Part IV will discuss teacher collaboration and reflective practices and its effect on brain-based teaching, and Part V will review methodologies that provide a foundation for the design of this study.

Part I: The Brain and How It Functions

The first section of this review will be separated into three subtopics: nature and nurture; making connections; and regions of the brain. Nature and nurture looks at how genes and environment impact the brain's ability to learn. The section on making connections explores how the brain cells connect and make patterns, and regions of the brain examines areas of the brain and their significance to learning.

Nature and Nurture

"The brain is not a computer that simply executes genetically predetermined programs. Nor is it a passive gray cabbage, victim to the environmental influences that bear upon it" (Ratey, 2001, p. 17). Rather, genes and environment work in tandem, like two sides of the same coin, to shape the way our brain develops throughout life. Genes, the chemical blueprint, establish the framework for the brain and the environment provides the fine tuning (Kotulak, 1997).

Plomin and Kosslyn (2001), reviewing research on the influence of genes on the brain's structures, reported that the volume of the gray matter (the neural cell bodies) seem to be genetically controlled. On the other hand, the white matter, which consists of the connections between neurons, "might be expected to differ among individuals as a result of experiences" (p. 1153).

According to Jensen (1998), today's consensus tells us that heredity provides 30 to 60 percent of the brain's wiring and 40 to 70 percent is the environmental impact. The variation depends on the specific trait or behavior being considered and the complex environmental variables of circumstance, opportunities and skills learned. Ratey (2001) proposes that it is difficult to determine the impact of an environment on an individual since we can't "isolate out" the influence of the genes. Even in the earliest stages of development as a young embryo in the mother's womb, genes do not operate completely independently from the outside world. Rather, the embryo is in direct contact with the body chemistry of the mother (LeDoux, 2002).

Thus, genes, environment, selection, instruction, and learning all contribute to the building of the brain and the shaping of the developing self throughout our lifetimes. "The human brain's amazing plasticity enables it to continually rewire and learn—not just through academic study, but through experience, thought, action and emotion" (Ratey, 2001, p. 47).

Although, experiences create and nurture complex connections among neural structures, these structures do not grow instantaneously, but require time to grow. The amount of time can differ depending on an individual's nature and aptitude for a particular skill or subject, or their prior experience (Armstrong, 2000). Given the differences among individuals' learning styles, genetic and environmental influences suggest that learning is promoted both by the biology and ecology of the child, that is, the child's capacities and the environmental supports (Bransford et al., 2000). In such a setting, pedagogy that acknowledges individual differences in learners, but also recognizes the brain's capacity for change, focuses on optimizing a learner's experience through stimulating activities that promote the brain's synaptic growth.

<u>Making Connections</u>

The brain is not a neatly organized system; it is highly complex containing more than a hundred billion brain cells called neurons. When neurons are activated, they branch to other neurons through treelike projections known as axons, output channels, and dendrites, input channels, which terminate in tiny structures called synapses, the junction in the brain through which information passes. Each one of the hundred billion neurons could have one to 10,000 synaptic connections to other neurons. Like the Amazon rain forest that stretches for 2,700,000 square miles and contains about a hundred billion trees, the vast number of connections could be compared to the leaves on the trees in the Amazon jungle (Greenfield, 1997). “This means that the theoretical number of different patterns of connections possible in a single brain is approximately 40,000,000,000,000,000—forty quadrillion” (Ratey, 2001, p. 9).

At birth, the human brain has only a relatively small proportion of the trillions of synapses it will eventually have; it gains about two-thirds of its adult size after birth. By puberty, the average brain has as many as 500 trillion conduits that are ready to flash messages between brain cells. Only those synapses cultivated by repetitive sensory stimuli will survive. “The number of connections can easily go up or down 25 percent or more, depending on whether a child grows up in an enriched environment or in an impoverished one” (Kotulak, 1997, p. 16). In the absence of proper stimulation a brain cell will die. But, if offered a diet of enriched experiences its neural synapses sprout new branches and connections, thus, continually changing the structure of the brain by reorganizing its ever-evolving wiring system.

Neurons that repeatedly fire together, wire together and lay down over the axon a multilayered covering called myelin. As patterns form, myelin increases the speed of nerve impulse transmissions. In a highly myelinated neuron, impulses travel at 100 meters per second. Like driving fast on a superhighway, the more myelin, the faster the brain processes information. However, Hannaford (1995), points out, “When we first learn something, it is slow going, like beating a path through untraveled terrain” (p. 21). It takes a great deal of practice using the executive part of the brain, the cerebral cortex, which is responsible for conscious thoughts and actions.

Once a skill is mastered, it becomes automatic and moves down to the subcortical areas of the brain. When a procedure is stored in this lower memory it becomes hard-wired freeing up neurons initially recruited for the learning process to go to other assignments (Ratey, 2001). “Since the amount of information a person can attend to at any one time is limited, ease of processing some aspects of a task gives a person more capacity to attend to other aspects of the task” (Bransford et al., 2000, p. 44).

As processing becomes automatic, it helps the brain function more efficiently. When working properly, the brain shifts back and forth between deliberate and automatic cognition. “This ability, which is largely taken for granted, allows us to perform many different tasks at the same time (Ratey, 2001, p. 160). In almost all activities such as driving a car, playing basketball or reading, the brain must recognize and respond to hundreds of inputs per second. It processes data in nano-seconds (billionths of a second) and sends out information through synaptic points. Processes like regulating heart rate, breathing rhythm, stomach contractions, and posture, to controlling many aspects of seeing, smelling, behaving, feeling, speaking, thinking, evaluating, judging, believing, and imagining are unconscious processes, which account for much of mental life and are probably as important for day-to-day functioning as what we know consciously (LeDoux, 2002).

> When someone speaks to you, for example, you decode sentence meaning on the basis of the sound of the words (phonology), the meaning of the words (semantics), the grammatical relations between the words (syntax), and your knowledge about the world (pragmatics). You usually are not aware of performing these operations, but simply do them. While you end up consciously knowing what the person said, you don't have access to the process that allowed you to comprehend the sentence. (p. 11)

The brain's ability to activate several different functions simultaneously indicates a high number of connections between neurons and a high degree of interaction in various parts of the brain. Based on how frequently groups of synapses fire, these cell assemblies are constantly making subtle changes. Subsets of several thousand neurons act as an ensemble when the connections between them are briefly strengthened by repeated, synchronous firing (Czerner, 2001). Activating one assembly can lead to the activation of others, and these fundamental building blocks can quickly organize themselves into more detailed perceptions, more elaborate memories and more complex behaviors. The notion of cell assemblies will be further explored in the next section, regions of the brain, which is divided into five subtopics: perception, cognition, behavior, language and reading.

Regions of the Brain

Cell assemblies do not respect the borders of the brain's anatomical regions; rather, boundaries continually change as neurons compete to make connections. Neuronal plasticity creates a difficulty in accurately matching specific regions of the brain to the function they control. Connections that receive input from frequently used body parts, for example, will expand and take up more area than those that receive input from infrequently used body parts. "An accurate map of the brain would be different for each of us and would shift over time" (Ratey, 2001, p. 35).

In addition, brain functions in one region of the brain that have sustained damage can be replaced by neurons from other areas of the brain. For example, stroke victims often times are able to recover capabilities they experienced before the stroke, although the new neural connections may be less efficient. Brain functions, therefore, need not belong to one particular region or population of neurons. "How otherwise could recovery of function occur if the original cells in question, with their exclusive monopoly, were dead?" (Greenfield, 1997, p. 24).

Although, neuronal plasticity demonstrates the brain's amazing ability to compensate and rewire with practice, it does not suggest that the brain is a single uniform multifunctional system, nor is it a collection of autonomous centers. "It is a most curious blend of the two" (Czerner, 2001, p. 34). Brain imaging techniques, such as the magnetic resonance imaging, (MRI), or positron emission tomography (PET), which tracks the use of oxygen or glucose by the brain, have revealed the brain's ability to simultaneously utilize multiple regions to accomplish a specific task. When the task changes, such as hearing words rather than speaking words, a different constellation of brain regions appears.

Thus, distinct brain regions are shown to combine in a parallel effort to accomplish complex functions. Unlike computers that process information in a serial fashion, one after the other and each in a matter of microseconds, neural circuits, which operate in milliseconds, one thousand times more slowly than computers, are able to speed up the process by allowing information to travel along parallel neural circuits simultaneously. “Parallel processing is essential to our ever-changing interconnected network of neurons. The activation of one particular firing pattern can inhibit or excite other firing patterns, which accounts for the existence of complex mental phenomena” (Ratey, 2001, p. 195), such as perception, cognition, emotion, behavior and language.

Perception

Perception is a complex, multi-layered processing skill that uses varying regions of the brain to sift through millions of bits of fragmented, seemingly unrelated sensory information to form a coherent, meaningful unit. Sensory stimuli enter the brain in more or less an undifferentiated form as a stream of electrical pulses created by neurons firing along a certain route. What makes one stream into vision and another into smell depends on which neurons are stimulated (Carter, 1999). The brain distributes millions of bits of information and somehow reassembles them, according to a person’s memories and past experiences.

For example, the eye's retina, splits incoming information into specialized systems that carry only specific types of details. The visual attributes of an object are assembled in several parts of the occipital cortex. Neurons in the main area of the visual cortex extract detailed information about form. Adjacent cortical areas specialize in determining color, motion, and depth perception. Thus, rather than one visual cortex there are several, each specialized for a special function to work simultaneously. At the same time visual attributes are assembled, the sounds associated with an object are formed in the temporal lobe. The smells, ideas, and emotions attached to it are simultaneously transmitted to and processed by other regions of the brain.

The sight of a loaf of fresh bread, for example, leaving the oven and its distinct aroma are bound together by the coordinated timing and simultaneous activity of neurons in the olfactory cortex near the front of the brain and in the visual cortex at the back.

> The synchronous firing of their signals at forty spikes per second (40Hz) is what binds together the sight of the bread, its fresh-baked aroma and perhaps, in another area of the cortex, an extraneous childhood memory of your mother's kitchen. The result is a single, experienced perception. (Czerner, 2001, p. 161)

Perception ultimately determines how we think and view our world. Based on our unique experiences in life and genetic make-up, perceptions vary enormously and influence the perceptual filters that we develop. The brain is immersed all the time in a field of sensations, images and input. What the brain attends to is determined by an individual's interests and needs.

As the brain processes sensory input, it focuses on certain stimuli in order to seek out meaningful patterns. In this way the brain filters out competing stimuli in order to negotiate an environment and not become overwhelmed by it. Given the variation of how students perceive information, Wolfe (2001) advises teachers to articulate a lesson's objective so that students can anticipate critical features or ideas and increase the likelihood that the brain will focus on essential information. The way information enters the brain affects its final state as much as any other step in cognition (Ratey, 2001).

Cognition

Attention and consciousness are the foundation of how we create and understand our world. The frontal lobe of the brain's cortex, the area responsible for higher order thinking, synthesizes, organizes and coordinates inner and outer sensory data required for planning and self-regulation.

The ability to focus attention by blocking out irrelevant stimuli is driven by the relationship between working memory and long-term memory. Working memory and long term memory allow us to prioritize certain stimuli over others by keeping the less important issues circulating in the background. It is a significant part of the executive functioning of the prefrontal cortex because without the interaction of working memory with long-term memory, we would be unable to make decisions or predict future outcomes.

"Working memory is one of the brain's most sophisticated capacities and is involved in all aspects of thinking and problem-solving" (LeDoux, 2002, p. 175). It allows a space where data, ideas and motivations can be held together and manipulated for a bit as the long-term memory system encodes information to other parts of the cortex. Thus, as a person juggles information, shifting back and forth from one object or thought to the next, working memory helps an individual stay focused and derive meaning as it integrates information from verbal and nonverbal specialized systems (the way something looks, sounds, and smells).

These specialized systems in working memory, according to Baddeley (1986), are the central executive, the phonological loop and the visuo-spatial sketchpad. The central executive coordinates information from the two slave systems—the phonological loop that stores verbal information and the visuo-spatial sketchpad which processes and stores visual information. When working efficiently, these systems enable the mind to conceptualize immediately occurring events and manipulate information. Skilled thinking, problem solving, and learning depend on how well we can efficiently store, process, and move information into and out of working memory (Bruer, 1993). When the mind cannot retain the pieces of visual or verbal patterns long enough to make sense of them, it is forced to work with fragmented information. “An impaired attention span, the culprit in ADHD (attention deficit hyperactivity disorder), can make life seem incomprehensible, indistinct” (Ratey, 2001, p. 130). Those individuals with ADHD are thought to have a working memory deficit and it has been suggested to be associated with an impaired function of the frontal lobe (Rubia, 1999).

The brain relies on patterns in order to predict what lies ahead. Without patterns nothing makes sense. As with all animals that move, there exists some sense of predictive power in order to navigate through an environment. Building these navigational aids forms the basis for ongoing activity in the brain. For example, we develop models of what we expect to hear: phonemes, words, music. As we perceive sound it either fulfills our expected models or surprises us. Ratey (2001) writes that individuals who have auditory processing problems often associated with dyslexia, are continually being surprised because nothing they hear seems to fit the models. “They must guess or intuit a lot more than most of us about what they hear” (p. 91).

The brain is continuously making elaborate mental maps of how it perceives the world. As an individual experiences life, these mental maps are revised and updated. This is why early learning in life is so important for children because what is learned early on becomes the foundation for subsequent learning.

> Indeed, much of the self is learned by making new memories out of old ones. Just as learning is the process of creating memories, the memories created are dependent on things we’ve learned before. (LeDoux, 2002, p. 96)

Thus, for learning and instruction, the most important feature of long-term memory, the permanent storehouse of knowledge and skills, is not its capacity, but more importantly, its networking efficiency for acquiring, processing, and storing general knowledge about objects, events, or situations. Psychologists refer to these associative structures as schemas. When we learn something new, the information is not passively inscribed at the end of our memory tape; rather, it is integrated into a preexisting schema (Bruer, 1993). These associative structures influence the way we notice, interpret, and remember. Thus, effective instruction considers a student’s prior experiences.

Maintaining and organizing the order of information and integrating it with previously learned data allows us to monitor and evaluate ourselves in a variety of mental settings and to project future outcomes. Instrumental in this process is motor activity, which not only instructs physical movement, but is also crucial to some forms of cognition (Ratey, 2001). Brain imaging techniques that show higher executive functions, such as thinking and planning, incorporate the primary motor cortex and premotor cortex in the frontal lobe of the brain while receiving a convergence of inputs from other areas to plan movements. Likewise, movement, controlled by the cerebellum, located in the back of the brain, becomes inextricably connected to cognition, specifically memory, emotion, language and learning as evidenced in neuroimaging studies where the cerebellum becomes active when individuals recall a list of letters or search a pattern for a specific image (Bower & Parson, 2003).

“Evidence is mounting that each person’s capacity to master new and remembered information is improved by biological changes in the brain brought on by physical activity” (Ratey, 2001, p. 178). Exercising the body strengthens the brain’s utilization of the right and left hemispheres by sequencing motor actions with information and memory. Through physical activities, the corpus callosum, which connects both hemispheres of the brain, develops and speeds up the communication between the hemispheres so that ideas and concepts can be optimally manipulated resulting in formal reasoning (Hannaford, 1995) and more complex behaviors.

<u>Behavior</u>

Strengthening synapses within a group of neurons through repetition of a behavior produces a more developed skill and, for better or worse, an automated response. Skills and habits that are continuously reinforced are stored in and executed from the brainstem, base ganglia, and cerebellum in the lower brain where they reside as more automatic programs. Once a program is stored in the lower memory it becomes hard-wired (Ratey, 2001).

Learning changes the brain's pattern of thinking and structure. For instance, the brain is able to adapt new behaviors to replace old, problematic ones. High tech imaging devices showed that behavior therapy produced the same kinds of physical change in the brain as psychoactive drugs (Kotulak, 1997). "Obsessive-compulsive patients who changed their problematic behavior by repeatedly not giving in to an urge, and deliberately engaging in another activity instead, showed a decrease in brain activity associated with the original, troublesome impulse" (Ratey, 2001, p. 36).

Brain restructuring also occurs through a neurological phenomenon called cross-modal influences—cross training in the sports world. Because many cognitive functions share pathways in the brain's complex tangle of neural connections, the development of one skill can profoundly influence another that is seemingly unrelated. "Music and spatial reasoning appear to be linked. Listening to words and reading share some of the same circuits, too" (Ratey, 2001, p. 42).

Activities in life that challenge the brain actually expand the number and strength of neural connections devoted to that skill. Puzzles strengthen connections involved with spatial skill, writing boosts language skills, and debating helps reasoning networks. Also, music appears to increase brain power by exercising the same circuits employed in memory formation (Kotulak, 1997).

"Studies show that creative people have a higher degree of cortical arousal" (Ratey, 2001, p. 206). It may then be conceivable that practicing a musical instrument or dance step leads to an increased cognitive capacity. For example, playing the piano exercises the entire brain—the eyes for reading the music, the ears for listening to sounds, and the fingers for manipulating the keys. Utilizing both hemispheres of the brain, the right for creative interpretation of the music, and the left for manipulation of the instrument, increases a person's mental acuity and memory.

> Along with parallel processing that must occur to evoke sounds from the instrument, the musician is constantly adjusting decisions on tempo, tone, style, rhythm, phrasing, and feeling—training the brain to become incredibly good at organizing and conducting numerous activities at once. Dedicated practice of this orchestration can have great payoffs for lifelong attentional skills, intelligence, and an ability for self-knowledge and expression. (Ratey, 2001, p. 206)

Language

It is interesting to note that language is recognized by similar brain circuits required for music (Ratey, 2001). Language centers and music centers are distributed throughout the brain. "Unlike vision or touch, which stay in specific areas, language can shift to different cells at opposite sides of the brain when need be" (Kotulak, 1997, p. 29). Location of language functions can also vary significantly from one person to the next.

Language acquisition, which is thought to be instinctive (Shaywitz, 1996), came late in the genetic evolution. It is a very recent phenomenon thought to have only existed for the past 50,000 years. "It is so new that it acts like a guest, not yet claiming a permanent position in the brain as do vision, smell, or hearing" (Kotulak, 1997, p. 29).

However, although language functions are distributed throughout the brain, they are predominately located in the left hemisphere for 90 percent of the people. Brain-imaging technology shows that the left side of the brain processes information faster than the right side, a skill that is important for separating sounds of speech into distinct parts (Ratey, 2001).

In children with normal language skills, the left side is bigger than the right. Such lopsidedness demonstrates how the brain specializes in certain activities—the left side dealing with details, the parts and processes of language, and linear patterns, and the right side dealing with whole processing of images, emotion and intuition. However, people with language disorders, according to studies by Tallal (1994), found that both sides, the right and left hemispheres, were of equal size and activity. "Having both sides equally active meant that the left hemisphere was underpowered" (Kotulak, 1997, p. 30).

Reading

Unlike language acquisition, which is a biological process, reading and writing are not natural abilities prewired in the brain. "There are no 'reading centers' in the same way that there are cortical centers committed to speech and language comprehension" (Wolf, 2002, p. 1). Rather, brain imaging shows that reading is a three-ring cortical, subcortical, mid-brain, and cerebellar parallel processing act, which makes biologically novel use of no fewer than seventeen regions in the brain, and integrates them in milliseconds. Reading is an example of the brain's Picasso-like capacities to create an evolutionarily new function from other things: like seeing small visual features, hearing discrete sounds, and retrieving names for things (Wolf, 1991; Wolf & Bowers, 1999). The failure to acquire reading can be based on an inability of these regions to work automatically and in precisely timed synchrony.

With reading, words are processed as visual representations of letters that are grouped into predicable patterns. The task of the reader is to transform the precepts of alphabetic script into linguistic ones—that is, to recode graphemes (letters) into their corresponding phonemes (sounds) (Shaywitz, 1996). Reading is further sped up by regularity of the words, and our previous knowledge. As these unified groups of neurons learn to work together in precise synchrony, frequently viewed stimuli (words) becomes so efficient, it is virtually automatic (Wolf, 2002).

We visually process words along parallel routes of sight and sound, each within its own separate neural system. The two independent routes may explain why some children learn to read better with phonics—sounding out words—while others learn with whole language techniques, where the whole visual word form is learned in context. However, according to Ratey (2001), most of us use both pathways simultaneously and learn to read by combining the two systems. "Whether schools should teach reading by phonics versus whole language has become a hot, almost political debate, but brain research provides a simple answer: they should use both" (p. 282).

A whole-language approach to reading adds efficiency to the reading process, but used alone is deficient, because phonics is so fundamental to linking sounds and symbols. The beginning reader must be consciously aware of the phonological structure of spoken words and the orthography—the sequence of letters on the page that represents this phonology. "That is precisely what happens when a child learns to read" (Shaywitz, 1996, p. 100).

Summary

The brain is a highly complex organ capable of receiving, perceiving, comprehending, storing, manipulating, controlling, and responding to a steady stream of data. The ability to link information from motor, sensory, and memory association areas is crucial for thought-processing and the ability to contemplate and plan future actions. Although we all have roughly the same number of neurons, the particular way those neurons are connected is distinct, and that uniqueness, in short, is what makes us who we are.

Part II: Brain-Compatible Learning—Implications for the Classroom

Functions of the brain are not necessarily pre-determined by birth, but can alter as a result of environmental influences. Acknowledging the brain's plasticity has significant implications for education. Traditionally, since the early 20th century, education has incorporated the behaviorist theory that presumes that learning is simple and predictable (Darling-Hammond, 1997). By using positive and negative reinforcements, students learn small discrete pieces of information in a predetermined sequence to ensure that upon graduation they will have all the skills necessary to live a productive life. However, schools have not kept pace with society's expectations (Bruer, 1997). The workplace needs people with higher order thinking skills who are critical, analytic thinkers, able to innovate and solve problems. According to the US Department of Education's National Assessment of Educational Progress (NAEP), most students are unable to solve complex problems that require several steps and have no obvious, immediate answer. "They can't rise above the rote, factual level to think critically or creatively" (Bruer, 1997, p. 5). If students are to have higher order thinking skills, Bruer maintains that new teaching methods and new approaches to education will have to be used.

Schools must first understand how the brain functions and fit instruction to best optimize the brain's natural abilities (Hart, 1983). The human brain is not organized or designed for linear, one path thought. It processes information using trillions of connections simultaneously. To proceed down a conventional one-way path uninformed and unguided by knowledge of the brain's true nature is to cripple and inhibit it. The traditional school environment, in Hart's opinion, is antagonistic to how the brain naturally learns, which is through pattern seeking and problem solving. "Coerced to operate in other ways, it functions as a rule reluctantly, slowly, and with abundant error" (p. xiv).

Knowledge stemming from the research of neuroscience distinguishes and supports educational practices rooted in a solid foundation already established for a child-centered curriculum (Liston, 1995). Many practices today that are considered "brain-based" have roots in old methods of instruction that effective teachers have practiced for years. Regardless of whether these instructional practices are known as exemplary practices, brain-based or just plain "good teaching," Kasper (2004) maintains that students' academic achievement will increase through consistent use of strategies advanced by current brain research. Educators who know how the brain learns have developed a variety of brain-compatible instructional strategies. In the following section, principles about brain-based practices and their impact on learning and teaching will be explored.

Brain-Compatible Education

Although strategies have been articulated by educators to aid classroom teachers in implementing brain-compatible instruction, there has been no research- and theory-based method for creating and delivering brain compatible curriculum to teach a complete unit, course, or sequential program from beginning to end (Smilkstein, 2003). Despite remarkable progress, brain research has not yet found significant application in theory or practice of education except in providing conjectures of whether or not the pedagogical approaches are headed in the right directions (Hung, 2003). Jensen (1998) agrees that while the research doesn't give us the specific form or structure for how to shift the paradigm, there is, however, enough information for educators to figure it out.

One of the problems with developing and delivering curricula that triggers and sustains the brain's innate learning process as well as the learner's motivation and attention, is that all brains learn differently. People are unique individuals with different cognitive strengths and cognitive styles. "These would include both inter-and intrapersonal variations in functioning and performance for different reasons in different situations at different times" (Smilkstein, 2003, p. 124).

Yet, even though every brain is different from every other brain, all brains are the same in one fundamental way: when they learn it is because they are growing and connecting neural structures, which is the physical cause and embodiment of their learning. In her book, "We're Born to Learn," Smilkstein (2003, pp. 71-72) outlines five rules of how the brain learns.

1. *Dendrites, synapses and neural networks grow only from what is already there.* We learn by connecting new learning to something we already know and then construct new levels of knowledge from the prerequisite foundation.
2. *Dendrites, synapses, and neural networks grow from what is actively, personally, and specifically experienced and practiced.* What we learn, we learn by doing. We need time to practice, making and correcting our own mistakes to gain our own expertise and in-depth understanding.

3. *Dendrites, synapses, and neural networks grow from stimulating experiences.* Stimulating experiences arouse the brain to use its innate resources to seek patterns, solve problems, and understand how the world works and how to make it work. Concrete experiences engage more of the senses and use multiple pathways to store—and therefore more ways to recall—information (Wolfe, 2001).
4. *Use it or lose it.* Through application and use, the brain strengthens the wiring of the neurons that pertain to a particular knowledge gained. However, if we do not use the knowledge we've gained, the neurons pertaining to that structure may weaken and gradually break up (Hung, 2003).
5. *Emotions are inextricably bound up with thinking, learning and rememberin*g. Emotions engage meaning and predict future learning because they involve goals, beliefs, biases and expectancies (Jensen, 1998).

How do these precepts about the brain and learning translate into school and teaching? Hung (2003) writes that although children are biologically motivated to make sense of their world and seek out situations that develop primary competencies such as language and social skills, it does not appear that they are compelled to learn to function in a technologically complex society. Thus, strong cultural support and guidance is necessary to help children acquire skills such as learning to read, solving complex math problems and developing the process of scientific inquiry.

In order to coordinate how the brain naturally learns with brain compatible strategies, Caine et al. (2005) propose 12 brain/mind learning principles (pp. 4-6) that emphasize the development of the executive functions in the brain's prefrontal cortex.

Growth of dendrites and synapses in the prefrontal cortex occur when students experience situations in which they are required to make decisions, apply knowledge to personally relevant questions and projects, reflect on their own thinking and accomplishments, and use critical thinking and feedback from others.

The 12 brain/mind principles, which are designed to help guide and foster effective teaching practices and help students to reach and sustain high standards of learning, are divided into three categories: *relaxed alertness*, *orchestrated immersion in complex experience*, and *active processing of experience*.

Relaxed Alertness

Caine et al. (2005) describes relaxed alertness as an optimal state of mind consisting of low threat and high challenge. Essentially the student is both relaxed and emotionally engaged at the same time. This state exists when the student feels competent and confident and is interested or intrinsically motivated. Relaxed alertness lays the foundation for taking risks in thinking, questioning, and experimenting, all of which are important for mastering skills. "One's neocortex functions fully only when one feels secure" (Hart, 1983, p. 111).

Within this category, there are four brain/mind learning principles: reduce threat and enhance self-efficacy; engage social interactions; engage their innate search for meaning; and engage emotional connections. The first of these, self-efficacy, refers to an innate belief in oneself and one's ability to achieve. When students feel comfortable with their own learning and learning environment, they recognize that learning is an ever-evolving process that takes time, includes trial and error, and builds upon success. It's the process of learning that strengthens and increases the synaptic connections in the brain. "Surprisingly, it doesn't matter to the brain whether it ever comes up with an answer. The neural growth happens because of the process, not the solution" (Jenson, 1998, p. 36).

Students who are comfortable with the notion of process (the ability to see how effort affects future outcomes) look for the essential steps leading to success. Bransford et al. (2000) refer to this self-regulation as metacognition, where students monitor their own learning, predict outcomes, note failures to understand, activate background knowledge, plan ahead, and apportion time and memory.

Building self-regulation and a sense of self-efficacy is enhanced when interacting with others, the second brain/mind learning principle. When students become socially capable, they are able to reflect on their own behavior and actions, have empathy for others, become flexible, positive, and have a sense of humor. It is the community that shapes students' perceptions of themselves, their interactions with others, and their interpretation of the world around them—all of which strengthen and develop pathways in the brain.

> The many intricacies involved in dealing with other people's ideas and perspectives, along with collective problem solving and challenges to one's own thinking, require students to develop areas of the brain located primarily in the prefrontal cortex. (Caine et al., 2005, p. 53)

Engaging students' innate search for meaning, the third principle (Caine et al., 2005), requires real understanding and leads to a shift in one's own mental model as new ideas and concepts are mastered. Meaning is essential for mastery. By making connections, the brain adapts and relates new ideas, skills, and experiences either personally or academically to what is already known. Because patterning is grounded in physiology, entrenched patterns are challenged or disrupted as new experiences reconfigure these automatic patterns. Thus, these physical changes to the brain's patterning takes time (Caine, Caine, & Crowell, 1999).

Time, however, in traditional school settings, is a very restricted commodity. Too often students are not allowed enough time in school to deal with anything in depth because the curriculum is overwhelming. The teacher's focus is deflected from educating students to covering curriculum. Content coverage is so severe that teachers feel unable to pursue ideas that derive from students interests (Darling-Hammond, 1997).

Engaging emotional connections**,** Caine et al. (2005) the fourth principle, encourage schools to support students' freedom to pursue work of a personal interest in order to cultivate and nurture a learning atmosphere that is pleasant and emotionally uplifting. A pleasant environment that allows student to choose areas of interest and opportunities to work alone, in pairs, or in small groups, can actually have an effect on the brain. The neurotransmitter dopamine is stimulated in just the right amount by pleasant feelings. That in turn, stimulates another neurotransmitter, acetylcholine, which directly stimulates the hippocampus, the major center for new learning. Individuals learning in such environments have better working memories, better episodic memory (memory for events), more options for solving problems, more flexibility in their thinking, are more competent in dealing with social relationships, have greater verbal fluency, and have better decision-making abilities (Caine et al., 2005).

Orchestrated Immersion in Complex Experience

The concept of immersion is multilayered where information and skills are woven together. It is based on the fact that powerful learning involves multiple experiences that challenge learners as well as interests them personally. This approach to teaching and learning is always framed by the standards. That is, the teacher gently guides students' inquiries and research to align with the district or state's expectations where teachers focus on what students will have mastered when they are finished with the experience. Students' learning is enhanced by way of complex, multiple experiences that include practice and application, such as the continuous and ongoing exchange of thoughts and information with others, novelty generated by questions that intrigue learners, and individual and collective research that requires critical thinking, analysis, and problem solving. "Through these processes, students learn to master the 'languages' of mathematics, history, writing, art, science, and other disciplines" (Caine et al., 2005, p. 109).

The four guiding brain/mind principles in this category are: engaging the learner's ability to perceive both details and the larger view; the physiology in learning; engage the learner's capacity to recognize and master essential patterns; and acknowledge and engage developmental steps and shifts in learning. The first of these refers to the brain's ability to see parts and wholes simultaneously. Because short term memory is limited to perhaps a half-dozen units of foreground information at any time, the brain chunks related pieces of information to make whole units. Thus, we see a person as a unit, not just individual components of the body. "Our conscious brain monitors the total sensory field while it simultaneously searches for and focuses on familiar, interesting, and important elements—separating foreground from background" (Hung, 2003, p. 8).

The brain's need to make connections is oftentimes ignored in traditional education, which focuses heavily on teaching skills and drills without first teaching how these parts are connected. Students taught in this superficial manner appear to be successful with multiple choice tests, but not successful with comprehending or connecting information or applying it meaningfully to problems requiring synthesis or manipulation of what has been learned (Darling-Hammond, 1997).

Making sense of experience requires both a big picture and its parts. Stories as well as innovative presentations, simulations, moral or ethical dilemmas, projects, video clips, artifacts, art, music, and poetry enhance learning and generate a sense of connectedness, wholeness, and meaning. Substantive learning rarely occurs when students are presented large amounts of seemingly unrelated information or when students memorize facts divorced from major themes, concepts, or principles (Caine et al., 2005).

Engaging the physiology of the brain, the second principle, relates to this perspective of wholeness in learning. A multi-sensory environment in which a student is offered the opportunity to "see, hear, say and do" the curriculum results in a 90% to 95% retention rate (Jensen, 1998). "Students engaged in hands-on-learning opportunities, projects, discussions, and research aimed at higher-order thinking are better able to remember and apply what they have learned than are rote learners" (Darling-Hammond, 1997, p. 55).

Immersing the multiple capacities of the brain so that they support and reinforce each other is achieved through complex environments where learning involves the brain, mind and body. To fully engage ideas, construct meaning, and remember information, students must regularly employ the whole range of communicative media—speech, writing, drawing, poetry, dance, drama, music, movement and visual arts (Armstrong, 2000). Organizing and linking information through various means makes the units of memory larger and more meaningful. When students are helped to discover relationships, to group related concepts and ideas, and to see how information connects to their lives, comprehension is increased and recall is enhanced (Bruning, Schraw, & Ronning, 1999).

Engaging the learner's capacity to recognize and master essential patterns, the third principle, is essential to developing the frontal lobes of the brain. Research shows that the brain is capable of both automatically registering the familiar while seeking and responding to new stimuli (Caine et al., 1999). However, helping students see interconnected patterns is difficult in traditional schools because most school learning splits the curriculum into separate subjects that appear to have little in common with each other (Caine et al., 2005). Research in developmental and cognitive psychology suggests that individuals learn best when information is embedded within meaningful contexts, applications and multiple representations are provided, metaphors and analogies are created, and opportunities are available for learners to generate personally relevant questions (Brooks & Brooks, 1993; Mason, 1996). Interdisciplinary and cross-disciplinary models help students see ideas in relation to each other as well as how individual facts become meaningful in a larger field of information. Through discussion, arts, projects, or visual thinking, students can make more meaningful patterns (Jensen, 1998).

Because development of the brain does not happen in isolation from a broader context, an individual's ability to make meaning is dependent on scaffolding where a teacher builds upon what the student has learned or experienced before. By acknowledging and engaging developmental steps and shifts in learning, the fourth principle, educators seek to guide each student's development by helping him/her master skills. According to Hart (1983) mastery of a skill requires that each individual achieves 100 percent before going on to the next level of skills. In traditional schools, passing a class does not require that you've mastered the material, only that you have passed 60 percent of the tests and assignments. However, Hart points out that we would not feel comfortable flying with an airline pilot who got 60 percent in landings.

> When mastery is demanded in basic areas of learning, the setting changes from one which emphasizes scraping over hurdles to get credentials, to one in which solid learning takes priority, is expected, demanded and achieved. (p. 134)

Because of the complexity of learning, one standardized form of assessment does not demonstrate the depth of a student's mastery of skills or ability to connect and process knowledge. Multiple forms of assessment are used, such as, portfolios, videotapes, demonstrations and exhibits. The mastery approach embraces the notion that learning and human development are nonlinear and messy, much like an unplanned jungle. The developmental path is unpredictable and spontaneous. A fairly complex environment that includes many sensory, cultural, and problem layers more closely related to the real world provide a more compatible setting for stimulating the brain's neural networks (Hung, 2003). In such an environment where education focuses on building upon the learner's abilities and construction of knowledge, rather than measuring one's success with imposed skills, teachers exercise flexibility, adaptability and creativity, that is, "in the moment" or fluid kind of teaching (Caine et al., 2005).

> Research has shown that teachers who plan with regard to students' abilities and needs and who are flexible while teaching are more effective, especially at stimulating higher-order thinking, than teachers who engage in extensive preplanning that is tightly focused on behavioral objectives and coverage of facts. (Darling-Hammond, 1997, p. 72)

Active Processing

To fully capitalize on a student's experience, Caine et al. (2005) suggests that there should be "in the moment," on-going consolidation that solidifies and expands knowledge. Active processing, the third category, embraces the notion that powerful learning and adaptive decision making require more action and effort by students. Experience needs to be processed. Thus, the teacher provides many opportunities to engage students' interests and deepen their thinking. Active processing ranges from systematic practice and creative rehearsal (for memorization) to the deeply probing and ongoing questions that test the limits of a learner's abilities to call on executive functions and respond within a real-life context.

In this category, there are four brain/mind learning principles: engage the capacity to learn from different aspects of memory; engage both focused attention and peripheral perception; engage both conscious and unconscious processing; and engage their individual styles and uniqueness. The first principle distinguishes between memory as an archive (memory that is consciously stored and recalled) and memory that is generated in context at the moment of acting and making decisions. "If we do nothing more than memorize, the facts and procedures tend to be useless in solving complex, real-world problems" (Caine et al., 1999, p. 173). Active processing is the key that enables a teacher to move away from providing information to ensuring that students have many opportunities to make personal sense of material and learn in depth (Caine et al., 2005), as in integrated thematic instruction, which cuts through traditional curricular boundaries and weaves together subjects and skills that are naturally found in life (Armstrong, 2000).

However, before a student can tie the overall concepts and themes together, the brain needs sufficient data with which to make a meaningful context. Patterns can be formed and constructed only when enough essential 'base' information is already known (Jensen, 1998). This requires that a sufficient amount of time be allowed for students to rehearse the information in order for it to gel or consolidate. Meaning is generated from within, not externally, so too much external stimuli inhibits the brain's ability to process. This finding suggests that students be allowed several minutes of reflection time after new learning. Writing in journals or discussion in small groups provides more opportunities for consolidation (Wolfe, 2001; Jensen, 1998; Smilkstein, 2003). Also, well-used questioning by both the teacher and the student is another strategy to help students observe and come to understand the ideas and skills that they are learning while simultaneously absorbing and retaining information (Caine et al., 2005).

The second principle, engage both focused attention and peripheral perception, suggests that the brain/mind is immersed all the time in a field of sensations, images, and input while continuously selecting what to attend to and what to ignore. Attention is driven by what is of most interest or relevant to the satisfaction of wants and needs. There are at least two characteristics of attention: the first is that attention is selective and the second is the degree to which it is sustained (Caine et al., 1999).

Novelty, emotion, meaning and pattern recognition, influence a student's attention (Caine et al., 2005). Novelty refers to our brains innate ability to pay attention to any novel or unique stimulus present in the environment. (Wolfe, 2001). Emotions, too, play a key role in hooking and sustaining attention. People tend to pay more attention to things they feel strongly about and which are personally meaningful and relevant to their lives (Caine et al., 2005). As the brain searches for meaning, it filters out the irrelevant and attends to the familiar as it searches for and responds to novel stimuli. This matching of new input to stored information is called pattern recognition and is a critical aspect of attention. If our brains can find no previously activated networks into which the new information fits, the information is discarded as meaningless.

Attention is also influenced by the environment. "Peripheral stimuli are operating whether we like it or not" (Caine et al., 1999, p. 151). The brain continuously attends and responds to what is going on around it. Since sensory information impacts attitudes and states of mind, it must be acknowledged when considering the effect a classroom environment has on a student. A positive learning environment is one that creates a safe and comfortable atmosphere where a student feels free to learn. A key component to a positive learning environment is a competent and caring teacher, one who relates and values them and makes learning intellectually stimulating (Darling-Hammond, 1997).

The third principle, engage both conscious and unconscious processing, asserts that learning involves different layers of consciousness. Some learning requires consciously attending to a problem that needs to be solved, while other learning requires unconscious processing (incubation) where the solution occurs when a person is not thinking about it. Caine et al. (2005) suggest using the arts as a vehicle for helping students understand the curriculum and for priming unconscious processing. ”Students have permission to draw, mold, sculpt, and move to convey their understandings in different expressive ways” (p. 218). Humans both understand and reason about the world in a variety of ways and these ways are manifested in different forms of representation (Eisner, 1994). Through art, teachers further students’ understanding of the content they are studying by asking questions and making observations.

At the heart of conscious processing is self-regulation—the student’s ability to recognize what they are experiencing, what the dilemmas are, and that alternatives are available. Schon (1987) refers to this process as reflection-in-action, where students with the guidance of teachers construct their own learning through exploration of a problem. Skilled teachers help students think about their learning by having them articulate the thoughts guiding their actions and to judge their adequacy. One of the strategies in helping students be consciously aware of their learning process is through journaling and sketching (Caine et al., 2005).

Because each brain is uniquely organized, the fourth principle, engage their individual styles and uniqueness, suggests that all students can learn more effectively when their unique individual talents, abilities and capacities are engaged. Howard Gardner's Multiple Intelligence Theory takes into account that everyone has strengths and weaknesses and every student can benefit by strategies that fit their learning preferences as well as help them improve weaknesses in certain areas. Students' understanding of concepts increases when teachers expand their current teaching repertoire to include a broader range of methods, materials, and techniques (Armstrong, 2000). Through appropriate encouragement, enrichment and instruction students can develop the following eight different types of intelligences (Caine et al., 2005, p. 227).

1. Linguistic intelligence (ability to understand and work with language)
2. Logical-mathematical intelligence (ability to work with numbers categorization and reasoning)
3. Spatial intelligence (ability to visualize things accurately and transform images accurately)
4. Bodily-kinesthetic intelligence (ability to master one's bodily movement, the handling of objects)
5. Musical intelligence (ability to master music, including pitch, rhythm and timbre)

6. Interpersonal intelligence (ability to understand and identify others' feelings, emotions and motivations)
7. Intrapersonal intelligence (ability to understand oneself through insight)
8. Naturalist intelligence (ability to classify objects in the environment)

"Most teachers now focus on the linguistic and mathematical intelligences, neglecting the needs of students who learn best through the musical, spatial, bodily-kinesthetic, interpersonal, intrapersonal, or naturalist intelligences" (Armstrong, 2000, p. 109). Although Armstrong points out that lecturing and writing on the blackboard is a legitimate teaching technique, it is often overused. He suggests that other methods could be incorporated to address the multiple intelligences. For example, the teacher could use art and music, show a videotape, pass around artifacts or have the students build something tangible.

"There is no limit to the depth that is possible, and that much of the key to reaching and engaging students is a matter of increasing their options, then listening with more depth and questioning with more skill" (Caine et al., 2005, p. 233). Acknowledging different learning styles helps students see that there are different ways of doing things and that everyone has something to offer. Most important, is helping students develop an awareness about themselves and how they learn in order to empower them as active participants in their own learning process.

Summary

Although students will differ based on background, and genetic and physical makeup, each student has a natural capacity for learning that teachers can effectively address. Because the brain learns through experience, the teacher's job is to create experiences that help students engage the senses, make meaningful connections, make decisions, apply what has been learned, reflect on their own thinking and accomplishments, and use critical thinking and feedback from others. Providing a rich multi-sensory environment that embraces the arts, music, storytelling, drama, emotions and real-world context, engages students' interests and fosters better thinkers.

Part III: Studies on Brain-Compatible Educational Strategies

Brain-compatible education, that which bases its teaching strategies on sound principles derived from brain research, suggests that the more we understand the brain, the better we can devise instruction to match how the brain learns best (Wolfe, 2001). Educators are in the business of making an impact on students' brains to promote learning. Yet, some would argue that educational neuroscience is in its infancy and therefore, educational implications of neuroscience may be merely "speculation" or "a leap of faith" (Covino, 2002, as cited in Bertucci, 2006). Those who inspire teachers to try new methods may only be spinning stories about how brain research, as they understand it, supports their favorite educational practices (Bruer, 2002, as cited in Bertucci, 2006).

Despite these conflicting positions and in light of recent neuroscientific advances, a growing number of educational practitioners questioning existing teaching methods, support brain-compatible methodologies. Although multiple variables always exist and are difficult to control in educational settings, the following section examines studies which support brain-compatible education.

Brain-Based Studies

Pociask and Settles (2007) study was based on the current brain research that purports that in order to enhance learning, teachers should implement a multidisciplinary approach by providing students with many opportunities for hands-on activities, collaboration with other students and teachers, and real life examples. This research concluded that incorporating the Multiple Intelligence strategies into daily lessons improved students' self-esteem, increased retention rates, enhanced motivation for learning, and decreased incidences of off-task behavior.

Another study (Jackson, 2003) examined the effects of brain-compatible instruction on reading scores for grades 1 and 2 based on the Iowa Test of Basic Skills. This study included a comparison of average reading scores of two 5-year periods: the first 5-year period was prior to the brain-based instructional training, and the second 5-year segment was after the brain-based instructional training.

The findings in this study showed that brain-based teaching strategies for both the 1st and 2nd grade students lead to improved academic performance. For the first graders, the mean normal-curve significance (NCE) score before implementation of the strategies (50.88) was well below the mean NCE score after the implementation (67.14). The difference was statistically significant. The second-grade students showed even greater performance benefits, possibly because of an earlier exposure when they were first-graders. The NCE scores revealed a mean of 46.02 before implementation of brain-based instructional strategies, which was well below the mean NCE score of 68.36 after the implementation. The researcher concluded that brain-based teaching strategies yield significant and measurable benefits in terms of student performance outcomes when teachers are both trained in the use of such strategies and sustain the motivation to pursue success through their application in the classroom.

The Brain-Targeted Teaching Model (BTTM) is another method that has been successful in an inner-city mid-Atlantic elementary/middle school for three years. Student outcomes, including state standardized assessment results, have demonstrated strong academic growth for historically floundering students. The BTTM uses six interrelated teaching tenets that emphasize educational practices supported by brain research. They are:

1. Setting the emotional climate for learning, including personal connections, predictability, and humor.
2. Establishing the physical learning environment which may include visual stimulation, background sounds, and room arrangement.
3. Designing the learning experience which includes assessing prior knowledge, addressing content standards, and using a variety of learning strategies.
4. Teaching for declarative and procedural knowledge, for example, vocabulary development, automaticity in math, and highlighting story details. Procedural knowledge would include sequencing activities, brainstorming, and discussing themes.
5. Teaching for extension and application knowledge, which includes cross-curricular activities, arts integration, and applying skills beyond content areas. (Bertucci, 2006, pp. 75-76)

In another study, a brain-based intervention, Bridge to Achievement (BTA) accompanied by Accelerated Learning (AL) techniques, was employed to remediate cognitive weaknesses. Erland (2000) did a follow-up study on two of the original three fourth grade treatment classes. Three years after the intervention, the two classes revealed large academic achievement gains. Academic achievement had been previously at or slightly above grade level following the intervention the first year. Entering grade 7, these students, of whom 43 of the 44 had low auditory or visual memory encoding-decoding weaknesses, performed +1 to +3 ½ years above grade level. The study showed statistical significance against the national norms in all 13 primary academic achievement subtests in the Iowa Test of Basic Skills (ITBS) with the exception of one of the two classes not being significant in the math computation subtest, and the other class being significant in math computation.

The BTA cognitive skills, which consists of whole-brain, inter-sensory instruction for 30-40 minutes daily, Monday-Thursday for 48 days, accompanied by AL techniques, are designed to make all primary learning pathways (visual, auditory, tactile, kinesthetic) operational. The long, strong visual and auditory memory spans develop mental resiliency for learning efficiency through encoding-decoding practice.

In Erland's (2000) experience, the latent effects in academic achievement growth following immediate cognitive skill improvement with low scoring students, has been seen many times (Erland, 1999c, 1998, 1994, & 1989b). "It is important to realize that it may take more than one year for results to materialize for the low cognitive skill students" (p. 51). The researcher concludes that training cognitive skill deficiencies to enhance all learning styles should be recognized as a solution to diverse learning problems that thereby can most probably increase academic achievement test scores. "Unfortunately, this involves a paradigm shift as current popular intelligence theories advocate teaching to the student's strengths or talents, and not correcting the underlying problem" (p. 53).

In Omotunde's study (2006), the treatment group, 86 ninth grade students enrolled in physical science classes, were instructed by the learner-centered learning strategies of PALMS (Partnerships Advancing the Learning of Mathematics and Science), which incorporates inquiry-based learning, cooperative learning, and brain-based learning. The control group, comprising 75 students, was instructed by the teacher-centered traditional method of instruction, which consists of lecture and direct instruction. Analysis of the data showed that there was a significant difference between the test scores (average combined scores of selected chapters of the textbook and the district's six weeks test) of students who were instructed by learner-centered instructional methods and those who were instructed by teacher-centered instructional methods.

The researcher cited previous studies that support the idea that an active student-centered environment is conducive to learning science in high schools (Marzano, Pickering & Pollock, 2001; McManus, Dunn, & Denig, 2003; Schneider, Krajcik, Marx & Soloway, 2002). In the Schneider et al. (2002) study, for example, 142 tenth and eleventh grade students who were instructed to construct knowledge by inquiry outscored the twelfth graders (the national sample) by 44% of the test items on the 1996 NAEP.

Summary

Brain-based instruction, that which acknowledges the brain's natural ability to learn through problem solving and pattern-making, uses strategies to stimulate the whole brain. Studies on brain-based instruction, show increases in students' academic achievement and in developing the brain's executive functions that control the student's ability to plan and organize thinking, monitor learning, stay focused longer, and to think critically.

Part IV: Enhancing Brain-Based Practices through Teacher Collaboration

According to research on brain-compatible instructional practices, “Learning is more effective when it takes place as a collaborative rather than an isolated activity and in context relevant to the learner” (Osterman & Kottkamp, 2004, p. 16). As in Vygotsky’s zone of proximal development (Vygotsky, 1934/1986, 1978, cited in Sullivan & Glanz, 2006), the learner mediates and negotiates knowing by stretching just enough to construct new knowledge with the support of another in order to solve a problem. It’s through this mediation that an individual creates what Sullivan and Glanz (2006) term a “relational space” where a shared, mutual recognition takes place—not recognition of one person by the other, but recognition of both parties of themselves and the other. “This requires an understanding and ability to articulate and communicate our ways of processing our experience” (Sullivan & Glanz, 2006, p. 49).

> Through our understanding of our thoughts, feelings and actions a relational space is created where meaning is constructed from experience together, leading to a truly shared vision for learning and schooling. (p. 52)

Teachers who recognize the powerful impact reflection has on their own teaching and learning also realize that collaboration with their colleagues will both augment their professional knowledge and broaden their perspectives (Louis, 1992; Pugach & Johnson, 1990; Vinz, 1993; Wildman & Niles, 1987; Wildman, Niles, Magliaro, & McLaughlin; 1990, as cited in Toney, 1997). It is this duality of individual and social learning that is so integral to the conception of constructivism and brain-based teaching. Reflective practice permits the administrators and teachers to construct the self knowledge that facilitates the creation of the school culture (Sullivan & Glanz, 2006).

Building a community through a collaborative process shifts the focus of narrowed perspectives to encompass a broader, more inclusive perspective where participants recognize that their well-being is intimately connected to the well-being of the community (Chrislip & Larson, 1994). If all the adults in the school community are involved in this individual and social learning, they can proceed to incorporate the children in the reflective, constructivist learning process (Sullivan & Glanz, 2006).

Studies (Rosenholtz, 1987, 1985, & 1989, as cited by Smith & Scott, 1990) point to a strong association between collaborative practices and student achievement, school renewal, and teachers' openness to learning. "Moreover, schools whose teachers cooperate with one another are characterized by cooperation among students" (p. 19).

> Community is the tie that binds students and teachers together in special ways, to something more significant than themselves: shared values and ideals. It lifts both teachers and students to higher levels of self-understanding, commitment and performance—beyond the reaches of the shortcomings and difficulties they face in their everyday lives. Community can help teachers and students be transformed from a collection of 'I's" to a collection of 'we' thus providing them with a unique and enduring sense of identity, belonging, and place" (Sergiovanni, 1994, p. xiii.).

A community of learning, a purposeful place with a clear and vital mission, involves teachers, administrators, students and parents who share a vision of what the school is seeking to accomplish (Sergiovanni, 1994). This notion of shared responsibility among the stakeholders, creates a different conception of leadership, one that is founded on an interdependent relationship among people and their common interests, rather than a narrow, top-down management system (Chrislip & Larson, 1994).Espousing a broader view of leadership within a learning community, allows others to assume more responsibility and participate fully in shared decision making (Sullivan & Glanz, 2006).

> Democratic schools require stronger leadership than traditional top-down, autocratic institutions. The nature of leadership, however, is markedly different, replacing the need to control with the desire to support. Ironically, such leaders exercise much more influence where it counts, creating dynamic relationships between teachers and students in the classroom and resulting in high standards of academic achievement (p. 29).

In order to sustain collaboration for the long haul, Chrislip and Larson (1994) recommend that a climate of trust and openness be developed over time. They contend that initially this condition does not exist because stakeholders bring their own “narrowly defined parochial agenda and predetermined positions about acceptable outcomes” (p. 90). But given time, individuals can create a collaborative community by getting to know one another and discovering each others’ common interests, perspectives on problems, and shared aspirations for solutions (pp. 90-91). From there, participants develop a “shared ownership” of the collaborative process and its outcomes (p. 95).

In most schools, collaborative communities are not common (Sullivan & Glanz, 2006). Instead, teachers work in isolation, which according to Smith and Scott (1990) is a “glaring anomaly. One would expect that a profession dedicated to learning would be structured in such a way that its members could learn from one another” (p. 9). According to Rosenholtz (1985), professional growth is limited by the trial –and-error learning isolation imposes on educators. Teachers feel that they alone must “detect problems and discern solutions” (p. 350). Because of their lack of contact with their colleagues, they have no “models of teaching excellence to emulate” in their classrooms (p. 350). Smith and Scott (1990) also point out that given teachers constraints on time, “it is unfair and unrealistic to expect teachers to somehow find the time for collaborative activities and continue to do everything they are expected to do already” (p. 62). Educators need to recognize how collaboration will enhance their pedagogical and professional knowledge. Otherwise, collaboration will be viewed as ”too time consuming, costly, or disruptive of the status quo” to be worthwhile (p. 69).

Summary

Collaboration is more than just sharing information and knowledge with one another or to help each party achieve its own goals. The purpose of collaboration is to create a shared vision and joint strategies to address concerns that go beyond the purview of any particular party. Promoting and sustaining the collaborative process requires a climate of trust and openness where all members feel a sense of shared ownership in achieving high standards for academic achievement.

Part V: Research on Methodologies

In order to identify brain-based teaching practices and to assess their prevalence at a high school, three studies helped to guide the methodology for this study: Callela (1994) looked at teachers' knowledge and application of brain-based learning theory in relationship to their professional training; Smith (1999) investigated the impact of brain research on changing the instructional delivery of elementary school teachers; and Kaspar (2004) examined teachers' knowledge and the use of brain-based teaching practices.

In Callela's (1994) study, two original instruments were developed to measure the degree of diffusion and application of the principles of brain-based learning theory in teachers' formal and informal training activities. The first instrument contains two sections: the Teacher Personal Data sheet and the Principles of Brain-based Learning Survey. The Teacher Personal Data sheet consists of 10 questions relating to teaching experiences, educational degrees and certificates, and types of professional development in which teachers were involved. The Principles of Brain-based Learning Survey contains 18 statements that relates to the 12 principles of brain-based learning (Caine & Caine, 1991). A Likert-type scaling criteria scored responses culminating in a knowledge score for each participant. The second assessment tool was a checklist to record teachers' instructional behaviors consistent with the principles of brain-based learning.

Twenty-eight teachers were randomly selected from four districts for three classroom observations. Findings revealed that there were no significant differences in teachers' knowledge scores based on highest degree held or utilization of current educational literature. The findings, however, did show that specific types of teacher training activities were more influential in providing teachers information concerning the principles of brain-based learning theory and that teachers receiving this knowledge were better equipped to implement the theory in observable instructional classroom behaviors.

Smith (1999) designed her study to measure the instructional delivery of six randomly selected teachers, three who received an intensive five day workshop, and three that received no formal training. The workshop based on the Integrated Thematic Model (ITM), involved three components: brain research, effective instructional strategies and curriculum, and their application in the classroom. The researcher interviewed and observed the teachers over one school year. Assessments were made based on a fifteen-indicator rubric using brain-based criteria and indicators from Costa and Garmston's (1994) *Cognitive Coaching: a Foundation for Renaissance Schools.* These indicators were placed into Caine and Caine's (1997) three interactive instructional approaches: relaxed alertness, orchestrated immersion in complex experience, and active processing of experience.

Conclusions from the study indicated that only one of the three teachers trained in the workshop consistently allowed students to self-reflect and provide ongoing experiences for active processing. It was noted, however, that among all of the three trained teachers, the level of relaxed alertness and immersion were accomplished. One of the untrained teachers, who ranked third highest in points on the rubric and outscored one of the trained teachers by one point, also provided an "excellent climate for student learning" (p. 73). Among the three untrained teachers, the researcher also added that their classrooms lacked the "total immersion of the real-world context" (p. 74) in a rich sensory, hands-on, environment. Rather, these classrooms were more traditional with a variety of books and other examples of secondhand input.

Similar to Callela (1994) and Smith (1999), Kaspar (2004) used a rubric based on Caine and Caine's (1997) instructional approaches. However, unlike Smith's study that used these instructional approaches to assess the impact teacher training in brain-based instruction had on teachers' classroom practices, Kaspar used the rubric to help identify as well as monitor brain-based instructional practices currently implemented by six volunteer teachers.

Data for this research was collected in three phases. The first phase involved administering a Faculty Survey to all teachers in each school and the random selection of three volunteer teachers at each school to participate in an interview and two, thirty-minute classroom observations. The second phase of this study consisted of gathering data from the volunteer teacher's interviews and classroom observations. Based on the data gathered during the interview and classroom observations, each volunteer was provided an Instructional Approach Rubric to assist her/his future monitoring and adjustment of instructional practices to clearly reflect brain-based learning principles. The third phase involved triangulating the data from the Faculty Survey, the volunteer teachers' interviews, and classroom observations.

Kaspar (2004) concluded that although teachers at both schools recognized some of the brain-based principles of learning presented in this study, teachers in general have minimal knowledge of these principles and instructional practices. Data revealed conflicts between teachers' knowledge of brain-based principles of learning and what they actually "do" in their classrooms. The most often and commonly used brain-based practices among teachers were those that established "brain-friendly" classroom climates, that is, practices that include the use of games and celebrations to enhance learning and relieve stress, as well as humor, and the use of graphic organizers, the use of art, small group instruction, and peer tutoring. After triangulating the data from the surveys, interviews, and observations, it was also discovered that certain policies and educational practices of the participating schools conflicted with conditions suggested by brain-based research, such as, limited time for teaching and the lack of adequate school time set aside to plan for lessons. Also, standardized testing negatively impacted the amount of time teachers could set aside for presenting content and the kinds of learning activities they selected.

Summary

The three studies, Callela (1994), Smith (1999) and Kaspar (2004) used a rubric based on the 12 principles of brain-based learning (Caine & Caine, 1991, 1997) to assess teachers' instructional behaviors. In addition to observations, the studies also included surveys and interviews to identify and monitor the teachers' understandings of brain-based practices and to determine how teachers use these strategies in the classroom.

Although these three studies provided a foundation for this research study, there were some discrepancies. All three studies examined elementary school teachers, and the rubrics were not clearly defined: the 12 brain-mind principles were not aligned with the statements, and it was unclear as to what constituted frequent behaviors.

CHAPTER THREE: METHODOLOGY

In order to explore brain-based teaching practices in a high school (grades 9-12) in southwestern Idaho, this study sought to determine the consistency of teachers' perceptions of using brain-based teaching strategies with behaviors demonstrated in the classroom. Cumulative scores based on the results of teachers' self-reported surveys (see Appendix B) were compared to the scores given on a rubric. The rubric, which is aligned to the statements on the survey, served as a checklist during classroom observations (see Appendix A) to indicate the frequency of brain-based teaching strategies. Scores were used to determine the strongest overall competence with regard to brain based teaching strategies and how it related to the teachers' claims of using brain-based strategies. The study also included: in-depth, open-ended interviews with teachers (see Appendix C); field notes taken from classroom observations; and classroom artifacts such as assignments and students' writings, to provide evidence and clarify instructional procedures.

Setting

The high school in southwest Idaho is located in a growing community where subdivisions are replacing some of the surrounding farmland. The student population of 1,710 students is slightly below the maximum capacity of 1800. Of the student population, predominately white, middle to upper income, 150 students qualify for free or reduced lunch. There are 82 certified teachers, a principal and four assistant principals, five counselors, a security officer, a psychologist, a drug and alcohol interventionist, and 10 paraprofessionals. For the past five consecutive years, this high school has received the School of Excellence Award from the Idaho High School Activities Association (IHSAA) for excellence in academics, athletics, and citizenship and continues to meet AYP (Annual Yearly Progress) proficiency. In 2008, the school had a 98 percent graduation rate. Of the 409 graduates, 60 percent entered a 4-year college and 15 percent entered a two-year college.

The school offers a full range of classes including Advanced Placement courses in English Literature, Statistics, Calculus, Biology, Chemistry, Physics, Macro Economics, U.S. History, and Government and Politics. The school schedule consists of six, 60-minute periods and a zero hour for those students electing an earlier class in the morning which begins at 6:40-7:40. For most students (those not in zero hour) school begins at 7:45 and ends at 2:50. All classes in the school follow this traditional segmented plan, including an integrated 11^{th} grade English/U.S. History course, American Character, offered in two blocks, 2^{nd} and 3^{rd} periods, and 4^{th} and 5^{th} periods. In this setting, one large classroom is separated by walls that fold back allowing the history and literature teachers to teach both classes together or to fold the walls back together so that each discipline can be taught separately.

Participants

The school has nine departments: Mathematics (12 teachers); Language Arts (13 teachers); Science (11 teachers); Performance Arts (10 teachers), which includes photography, drama, music, visual art, and speech and debate; World Language (8 teachers); Vocational Education (4 teachers), which includes consumer science, video technology, keyboarding, and drafting; Physical Education (6 teachers); Special Education (6 teachers); and Social Studies (12 teachers), which includes U.S. government, history, and economics. A numerical chart describing this population was divided into five categories: subject area; years of experience; certification; gender; and age (see Appendix D).

In a pool of 82 teachers, 18 teachers, 22%, responded to the survey: two math teachers; three English teachers; three science teachers; three world language teachers; five history teachers; and two economic teachers. Although the response rate was not extremely high, the sample was representative of the population of teachers recruited to the study.

Concerning years of teaching, the population of 82 teachers (see Appendix D) showed that eight teachers, 10%, had taught less than one year. This group of teachers was not represented in the sample. However, similar to the population, which showed 32 teachers, 39%, had taught 1-10 years, the sample revealed that seven teachers, 39%, had also taught 1-10 years. Of the teachers who had taught 11-20 years, 27 teachers, 33%, were reflected in the population as compared to five teachers, 28%, in the sample. Of the teachers who had taught 21-30 years, nine teachers, 11%, were represented in the population as compared to five teachers, 28%, represented in the sample. Similar to the sample, 6 teachers in the population, 7%, taught more than 30 years and in the sample, one teacher, 5%, taught more than 30 years. Regarding education, the population of 82 teachers showed that 68 teachers, 83%, had undergraduate degrees, and 14 teachers, 17%, had masters degrees. Two teachers had National Board Certification. In the sample, 12 teachers, 67%, had undergraduate degrees, and six teachers, 33%, had masters degrees. Two teachers had National Board Certification. Concerning gender, the population of 82 teachers showed that 42 teachers, 52%, were females and 40 teachers, 48%, were males. In the sample of 18 teachers, seven teachers, 39%, were females and 11 teachers, 61%, were males. Concerning age, the population of 82 teachers showed that 10 teachers, 12%, were 22-29 years old. In the sample, none of the teachers were 22-29 years old. In the population, 28 teachers, 34%, were 30-39 years old, and in the sample, seven teachers, 38%, were 30-39 years old. Of the teachers in the population 21 teachers, 26% were 40-49 years old, as compared to five teachers, 28%, in the sample. In the population, 17 teachers, 20%, were 50-59 years old as compared to five teachers, 28%, in the sample. And, in the population, six teachers, 8%, were 60 years old and over, as compared to one teacher, 5%, in the sample. Regarding ethnicity, the population of 82 teachers showed that 79 teachers, 96%, were Caucasian, with one African American, one Asian, and one Hispanic. In the sample, 16 teachers were Caucasian, with one African American and one Hispanic.

All the teachers are highly qualified and all are endorsed in the subjects they teach. Because of the teachers' qualifications and the school's history of academic excellence, this school provided a viable sample for studying brain-based teaching strategies. In addition, the researcher as a member of the faculty will use this research to enhance teachers' and administrators' understandings of brain-based teaching strategies and how these strategies, if any, are currently being implemented.

Instruments

In Part V of the literature review, three studies that focused only on elementary school teachers, helped to guide the methodology for this study. Callela (1994), looked at teachers' knowledge and application of brain-based learning theory in relationship to their professional training; Smith (1999), investigated the impact of brain research on changing the instructional delivery of elementary school teachers; and Kaspar (2004), examined teachers' knowledge and the use of brain-based teaching practices. In those studies, the researchers designed rubrics for classroom observations based on the expertise of Caine et al.'s (2005) 12 brain/mind principles.

The researcher for this study designed not only a standard rubric based on Caine et al.'s (2005) 12 brain/mind principles (see Appendix A), but a twelve item teacher self-assessment survey that aligns with the rubric (see Appendix B). On the rubric, the 12 brain/mind principles were arranged in the following three categories: relaxed alertness, orchestrated immersion in complex experience, and active processing of experience. The survey, however, did not include the categories, but only listed the statements in order to simplify the instrument for the teachers' understanding.

To achieve face and content validity, the language of the statements in the survey and rubric was consistent with the concepts and language of the 12 brain/mind principles. Each statement included examples of behaviors that demonstrate brain-based teaching. The instruments, the rubric and survey, were not piloted; therefore, a panel of four experts was selected to review them. Their qualifications include more than 10 years of curriculum development and instruction, as well as a familiarity with the literature on the principles of brain-based teaching. The following 12 brain/mind principles will be reviewed and interpreted.

In the first category, relaxed alertness, where students are made to feel competent and comfortable taking risks in learning new skills, there were four statements. Each statement reflected each of the four brain/mind principles. The first principle, enhance self-efficacy, relates to students' ability to monitor and assess their own learning. Behaviors demonstrating this principle included: the use of planners where students set their own goals and monitor their progress; and self-evaluation techniques where students are encouraged to reflect (written or verbal) on their learning experience and take appropriate steps to reach success. The second principle, engage social interactions, emphasizes the notion that interacting with others builds camaraderie and helps students expand their thinking. Behaviors included: small group discussions, reading or writing with a partner, peer tutoring, or working together on projects. The third principle, engaging students' innate search for meaning, requires that the teacher allow time for students to make their own personal connections with the material in order to master new concepts. Behaviors included: student-generated questions; written reflections; and discussion, i.e., think/pair/share where students have time to think, share their ideas with someone, and then share with the class. The fourth principle, engaging emotional connections, supports students' freedom to pursue work of a personal interest, i.e., books, projects, demonstrations, research, as well as choosing to work alone or together.

In the second category, orchestrated immersion in complex experience, the four principles embrace the notion that powerful learning involves multiple experiences that challenge learners as well as interests them personally. The first principle, which involves the brain's ability to chunk information into whole concepts, required that teachers begin with the "big picture" before breaking it into parts. Activities included: stories; presentations; simulations; projects; and video clips. Related to this perspective of wholeness in learning, is the second principle, engaging the physiology of the brain, which recommends providing a multi-sensory environment in order to stimulate the brain's multiple capacities. Activities included: technology, speech, writing, drawing, art, poetry, dance, drama, music, and movement. The third principle, engaging the learner's capacity to see interconnected patterns was accomplished through interdisciplinary models, arts, projects, metaphor, analogies, or graphic organizers such as, compare and contrast, conceptual maps or cause and effect charts. The fourth principle involved using multiple forms of assessment to demonstrate the depth of a student's mastery of skills and ability to connect and process knowledge. Multiple forms of assessment were portfolios, presentations, essays, rubrics and student-generated tests.

Active processing is the third category, emphasizing the idea that powerful learning and adaptive decision making require more action and effort by students. The first principle distinguishes between memory as an archive (memory that is consciously stored and recalled) and memory that is generated in context at the moment of acting and making decisions. This principle suggests that in addition to the teacher using metaphors and analogies to increase understandings and retention of new ideas, students also be allowed time to consolidate new information. Activities included: journal reflections; discussions; paraphrasing; summarizing; questioning; applying the information to another situation or problem; practicing the concept; games; or creating mental models, i.e., graphic organizers. The second principle, engage both focused attention and peripheral perception, articulates two characteristics of attention: selectivity and sustainability. In order to direct student's attention, teachers are advised to state a lesson's objective so that students can anticipate critical features. In order to sustain students' attention, behaviors included: the use of humor; novelty; emotion; meaning; relevancy; as well as those behaviors that sponsor a safe, caring environment, i.e., encouragement, and lack of sarcasm or ridicule from students or teachers. The third principle, engaging both conscious and unconscious processing, incorporated strategies such as, journaling, sketching, and feedback to help students' construct their own learning and to be aware of their own learning process. The fourth principle, engaging students' individual styles and uniqueness, acknowledges Gardner's Multiple Intelligence Theory that all students can learn more effectively when their unique individual talents, abilities and capacities are engaged. Allowing students to develop an awareness of themselves and their learning style involved activities that emphasize the eight different types of intelligence: linguistic, logical-mathematical; spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal, and naturalist.

Surveys

Initially, the researcher personally introduced and distributed the surveys to each of the nine departments during their weekly collaboration meeting. Teachers were advised to sign a consent form (see Appendix E) and informed that if they chose to fill out a survey, they were giving their consent to participate in a 20-30 minute interview, and a one hour classroom observation. In the following week, teachers volunteered to fill out the surveys and drop them in a manila envelope marked “research” in a file cabinet in the main office.

Surveys required the teacher’s name and the classes he/she teaches. In addition, they were asked to include their years of teaching experience and academic degrees. (Pseudonyms have been assigned teachers to insure confidentiality.) Scores for the surveys were assessed as follows for each of the 12 statements: 0 points for those strategies that teachers never use; 1 point for strategies that are used sometimes; and 2 points for strategies that are frequently used.

Rubrics

Those teachers participating in the study were then observed during a one hour class session to determine if their perceptions of their use of brain-based teaching strategies were consistent with the strategies they demonstrated in the classroom. A check mark was given each time a behavior was used during the lesson. Therefore, there was an opportunity to receive several check marks in subcategories. For example, in Category 2 , orchestrated immersion in complex experience, multiple check marks could be given in subcategory 3 (see Appendix A) which asks: Does the teacher help students understand the concept before breaking it into parts? A teacher may begin the lesson with a story that illustrates the concept and later show a video clip. Each time the teacher demonstrates a behavior, a check mark is given in that category.

In addition, because the 12 brain/mind principles are interrelated, a check mark could be given in more than one category for the same behavior. For example, when students interact with one another, a check mark could be given in Category 1, relaxed alertness, and Category 3, active processing of experience. In order to further clarify the findings on the checklist, field notes were used as well as a self-reflection journal for anecdotal information and to examine personal biases that may affect the research analysis.

To insure that the rubric used for classroom observations was reliable, an inter-rater reliability study was used to measure the degree of concordance across independent ratings. The researcher and two volunteer teachers scored the rubric in reference to the same target teacher. The one hour video depicted a high school English teacher instructing an 11th grade Honors English class in a discussion on Thoreau. The raters were knowledgeable about brain-based teaching and were trained on how to use the rubric. Results of the study showed that the rubric could be used reliably. That is, there was strong agreement between the raters on each of the 12 items. Raters 1 and 2 were consistent 96% of the time and were never off by more than one check mark. Raters 1 and 3 were consistent 98% of the time, and never off by more than one check mark. Raters 2 and 3 were consistent 93% of the time and were never off by more than one check mark. The rubric was then used as a checklist to observe specific behaviors of teachers during a one-hour observation (see Appendix A).

Interviews

Upon careful analysis of the rubric and reflection of the field notes, a general open-ended interview guide (see Appendix C) focused the interviews on a similar set of issues, but allowed for more flexibility in addressing each individual's perspectives and experiences as questions emerged throughout the interview process (Patton, 1990). Questions were used to further illuminate a teacher's perception of brain-based teaching strategies as well as to investigate sources that have influenced a teacher's instructional methods. Each interview was transcribed and emerging themes and patterns were analyzed.

Analysis

A correlation analysis was used on the scores from the classroom observations and the scores from the surveys to determine the relationship between the two variables. By triangulating data from field notes, interviews, and classroom artifacts with the surveys and rubric, varied meanings and interpretations of incidents enabled the process of categorizing phenomena as being conceptually similar or dissimilar. By alternating between quantitative and qualitative data analysis, the researcher shifted between open coding, the analytic process of breaking down data to identify properties and dimensions, and axial coding, the process of reassembling data, in order to refine clarify, revise, and expand on categories and subcategories (Strauss & Corbin, 1998) to assess if teachers' perceptions of their use of brain-based teaching strategies were consistent with what they demonstrated in the classroom.

CHAPTER FOUR: RESULTS

This study explored the question: Are teachers' perceptions of using brain-based teaching strategies consistent with behaviors demonstrated in the classroom? By assessing the use of brain-based strategies in a high school (grades 9-12) in southwest Idaho, this study developed two original instruments which were aligned with Caine et al.'s (2005) 12 brain/mind principles. They were a 12-item self-assessment survey to measure teachers' perceptions (see Appendix B), and a 12-item rubric (see Appendix A) to serve as a checklist to measure teachers' behaviors during a one hour classroom observation. In addition, the study used field notes to clarify findings on the checklist, classroom artifacts, teachers' interviews and a self-reflection journal.

From a pool of 82 teachers (see Appendix D), 18 teachers volunteered for the study. Pseudonyms were assigned teachers to insure confidentiality. Each teacher filled out a survey and agreed to a one-hour classroom observation and a follow-up 20-30 minute interview. Classroom observations were scheduled with the teacher. Scores for the surveys were assessed as follows for each of the 12 statements: 0 points for those strategies that teachers never use; 1 point for strategies that are sometimes used; and 2 points for strategies that are frequently used. On a scale of 0-24 points, the results from the teachers' self-assessment surveys showed a range of scores between seven, which was the lowest score, to 22, which was the highest. The median score was 15.5, and the average score was 16.

Table 1

Faculty Surveys/Rubrics

Teachers (pseudonyms)	Years Teaching	Degree	Subject	Score for Survey	Score for Rubric	Quartile Survey Score	Quartile Rubric Score
Ms. Clyne	**30**	**BA**	**10th Honors History**	**7**	**94**	**1**	**4**
Ms. James	**3**	**MA**	**Conceptual/ Geometry**	**11**	**89**	**1**	**4**
Mr. Durham	25	MA NB	11th Am. Character	12	55	1	1
Mr. Bixby	33	BA	11th Eng.	13	68	1	2
Ms. Mason	17	BA	Alg.1/ Math Analysis	14	82	2	3
Ms. Jewel	10	BA	Latin	15	86	2	3
Mr. Cooper	11	BA	11th History.	15	61	2	2
Mr. Schwartz	16	BA	11th History	15	60	2	2
Mr. Reese	3	BA	9th Earth Science	15	51	2	1
Mr. Simmons	15	MA	12th Economics.	16	90	3	4
Ms. Vincent	24	MA	9th Honors Earth	16	77	3	3
Mr. Clark	7	BA	12th AP Economics	19	100	3	4
Mr. Hobbs	5	BA	Spanish	19	72	3	3
Ms. Tripp	25	MA	French	19	72	3	3
Mr. Story	**28**	**MA NB**	**11th Am. Character**	**20**	**70**	**4**	**2**
Mr. Farley	**9**	**BA**	**12thWildlife/ Anatomy**	**21**	**66**	**4**	**2**
Ms. Jolly	**11**	**BA**	**10th History**	**21**	**45**	**4**	**1**
Mr. Moore	**7**	**BA**	**9th Eng.**	**22**	**48**	**4**	**1**

Note: Teachers in bold were included as participants in the qualitative analysis.

The rubric served as a checklist during classroom observations to indicate the frequency of brain-based teaching strategies. Check marks were given each time a behavior was used during the lesson. Scores on the rubrics ranged from 45, which was the lowest score, to 100, which was the highest. The median score was 71.5 and the average score was 72. Scores were used to determine the overall competence with regard to brain based teaching strategies and how it related to the teachers' claims of using these strategies.

A correlation analysis examined the relationship between the cumulative scores from the teachers' self-reported surveys to the scores given on a rubric. For overall scores, the analysis showed $r = -.38$ ($p = .11$). For the three categories, the analysis showed: relaxed alertness, $r = .10$ ($p = .70$); orchestrated immersion, $r = -.08$ ($p = .77$); and active processing, $r = .16$ ($p = .49$). Thus, the quantitative analysis suggest there is not a relationship between teachers' perceptions of using brain-based teaching strategies with the strategies that they demonstrated in the classroom.

Six Teachers' Vignettes

The quantitative data derived from the rubric and survey showed no relationship between teachers' perceptions of their use of brain-based teaching strategies and the strategies they demonstrated in the classroom. Concerning this inconsistency, two themes emerged from the teachers' interviews that revealed limitations influencing teachers' ability and/or willingness to use brain-based teaching strategies in the classroom. The two themes were time constraints due to curriculum demands and standardized end of course exams; and students' issues, which include, student's lack of motivation; self-discipline; skills and/or aptitude; and accountability.

Although all 18 teachers were interviewed and observed in this study, data presented in this section focuses primarily on six teachers with the greatest inconsistency between perceptions and practice. They are: Ms. Clyne (Survey 7, Rubric 94), 10th grade Honors U.S. History; Ms. James (Survey 11, Rubric 89), Conceptual Math and Geometry; Mr. Story (Survey 20, Rubric 70), 11th grade U.S. History; Mr. Farley (Survey 21, Rubric 66), 12th grade Anatomy and Wildlife; Ms. Jolly (Survey 21, Rubric 45), 10th grade U.S. History; and Mr. Moore (Survey 22, Rubric 48), 9th grade English. Following the six teacher vignettes, an analysis will include data gathered from the surveys, rubrics, field notes, and interviews from all the teachers in the study to further clarify and support themes and patterns.

Ms. Clyne (Survey 7, Rubric 94)

Ms. Clyne has taught for 30 years. She has a bachelors degree in American History and is working on a masters degree in Gifted and Talented Education. She is currently teaching 10th grade Honors U.S. History and 11th grade AP (Advanced Placement) History. On the survey, Ms. Clyne noted that she "frequently" uses multiple forms of assessment. On this item, she circled "essays" as the form of assessment that she uses, which could indicate that it is the only form she uses, in addition to the EOC (end of course) multiple choice exam. She also acknowledged that she "frequently" has the students' attention. She marked that she "sometimes" has students interact with one another. Also, she believes that she "sometimes" allows students time to process, and that she 'sometimes" provides students a multi-sensory environment. She did not check anything on seven of the twelve principles, which included: students assess their own learning; students pursue their own interests; helps students understand the concept before breaking it down into parts; helps students see interconnected patterns; students have opportunities to consolidate and apply learning; students have opportunities to construct their own learning; and teachers address more than one learning style.

The observation took place in her 4^{th} hour 10^{th} grade class. The room has 36 desks arranged in a U shape, four desks to a row. All the seats are occupied. On one side of a wall hang flags, including a confederate flag and an American flag. Several posters of presidents and other historical figures in American history are arranged on walls around the room. The teacher posed the statement: “Although using controversial methods, John Brown was justified in his actions to end slavery. “ Students copied down the statement from the overhead on a blank sheet of paper that they will use for note taking. The objective of the lesson is for students to assess the validity of the statement by substantiating their position with the facts presented in the teacher’s presentation. From their outlines, they will write a position paper to include both sides of the issue.

Ms. Clyne has taught her students a note taking strategy that helps them discern significant information. (Later, during the class, Ms. Clyne told the researcher that students struggle at initiating this process, but in the end they develop stronger cognitive abilities in writing essays and studying for tests. She says that in her class she empowers students to build the skills necessary to become successful, independent learners.)

Ms. Clyne started out with a Power Point presentation. She began by telling the students the tensions that were brewing about slavery during those times. She then described the views of abolitionist John Brown and the radical means he used to try to put an end to slavery. She said that it's believed that John Brown may have staged the uprising at Harper's Ferry as an act of martyrdom. (She pointed out on a map where the uprising occurred.) As she spoke, students were taking notes from the Power Point. Ms. Clyne included a political cartoon depicting the hanging of John Brown. She then showed them a video about John Brown, which is presented on two television sets in the front corners of the room and also on the overhead.

After the movie, Ms. Clyne expressed that this Civil War Unit is one of her favorite topics. "Ask me anything. I love this part of history." She has visited many Civil War battlefields and on one of the fields she found a bullet. She passed the artifact around to the students and explained to them that the saying, "Bite the Bullet," originated from the horrors of the battlefield where there was no morphine to suppress the pain when legs and arms were severed. So, in lieu of pain killers, soldiers would bite a bullet. With a few minutes remaining in class, students asked her questions about some of the battlefields. Essays would be due the next day.

Although the teacher used a "stand and deliver" approach, brain-based principles that emphasize a multisensory environment were demonstrated throughout the lesson to enhance student comprehension: art, film, maps, notes, an artifact, and a lecture filled with anecdotes and analogies. Students were actively constructing some of their own learning by using the note-taking process that she had taught them to gather information for their position papers.

Ms. Clyne emphasized that teaching students how to write position papers is a major area she focuses on in both the 10th grade honors class and the 11th grade AP class. They learn to debate and express themselves in their own writing. Discussions are not as frequent because of time limitations so she tells students to write about their views in their essays and make sure that their opinions are well substantiated with the facts. “It’s authentic achievement. It’s not that you show up every day. You have to learn the material. You have to study.”

Although it would seem that students in the honors class would proceed into her AP class the following year, she makes it very clear. “If you get into this class we may be taking a train sophomore year, but we’re taking a Concorde junior year.” She warns students and parents at the beginning of the year about the workload. “If you can’t keep up, we leave you in the dust.” Those who survive, she said, “tend to have self-efficacy.” She’s taught this course for 15 years and knows that students who are bright, but have poor management skills will suffer. “But, kids that have a good work ethic fly. They’re not afraid to have work stacked on them, they’re not afraid to read.”

The most frustrating part about teaching for her is the administrative control that oversees what she does in her classroom. “I firmly believe that what happens in a school is what teachers make happen in a school. It’s between teachers and students.” She said that she needs to be in charge of their learning or it won’t happen. “And that’s what it’s all about—their personal growth.” She has difficulty adhering to a double standard imposed by the administration. On the one hand, she says, the administration wants a rigorous academic setting, ‘holding the line,” but on the other hand, every child must succeed. She feels that by insuring that no child fails takes away students' accountability for being responsible for their own actions and deters them from participating in their own learning process.

In addition to the unrealistic expectations of the administration, are the expectations of the parent as well who agrees that standards should be high, but don't want their own children to be subjected to failing. Too often parents encourage their children to be in the higher level courses, but the student is not prepared and becomes frustrated and exhausted, which Ms. Clyne said, leads to contention with the parents. "I don't want them to hate the material, so if I can't serve them in a way that enhances their enjoyment of the past then give them to a teacher who can help them."

Ms. Clyne believes that students need to develop stronger cognitive skills to survive high school and beyond. In her classroom she teaches students note-taking and writing skills. Students were observed using these skills to discern significant information to incorporate in their position papers. Brain/mind principles emphasize activities that challenge and stimulate the brain's natural ability to construct meaning. By teaching students how to express themselves in substantive position papers, Ms. Clyne helped students strengthen and develop specific processing skills, i.e., organization, logical thinking, pattern-seeking, problem-solving and creativity.

Although, Ms. Clyne had the lowest score among her colleagues on the survey for using brain-based principles, the observation showed that the following principles were demonstrated often throughout the lesson. Concerning the brain/mind principle that recommends that the teacher helps the student understand the concept before breaking it into parts, Ms. Clyne indicated on the survey that she “never” does this. However, the observation showed that she “frequently” helped students understand the “big picture” surrounding the Civil War by using stories, maps, and an artifact (a Civil War bullet). Also, inconsistent with the survey, was her perception that she “never” helps students see interconnected patterns. However, the classroom observation revealed that she “frequently” helped students make connections. She used art, film, maps, notes, and a lecture filled with analogies, metaphors, and stories. Another inconsistency on the survey was her perception that she doesn’t provide students opportunities to construct their own learning and to consolidate and apply information. Yet, during the observation students were actively processing information by gathering notes to use for their position papers.

Ms. James (Survey 11, Rubric 89)

Ms. James, has taught mathematics for three years. She has a bachelors degree in biology and chemistry, and a masters degree in curriculum and instruction with a math emphasis. She believes that kids need hands-on activities, especially the lower level kids, in order to grasp concepts. She teaches conceptual mathematics, which is a course designed for students who need further instruction in pre-Algebra. She also teaches geometry.

On the survey, she checked that she “frequently” allows time for students to interact, and “frequently” provides opportunities for students to construct their own learning. She also noted that she “frequently” has students’ attention. On five of the items she marked “sometimes.” They were: students pursue their own interests; provides a multi-sensory environment; helps students see interconnected patterns; students have opportunities to consolidate and apply learning; and the teacher addresses more than one learning style. On four of the principles she marked “never.” They were: students assess their own learning; students have time to process information; the teacher helps the student understand the concept before breaking it into parts; and the teacher uses multiple forms of assessment.

The classroom observation took place in Ms. James 5th period geometry class that included 35 students. Desks were in a U shape with four rows of desks situated at each side of the room, and four rows facing the front. Ms. James first went over the problems from the homework on the smart board in the front of the room. Then she asked them about the shapes that they learned yesterday which included: a pyramid, a cylinder, a prism, and a cone. The students did several problems at their desks calculating shapes and she went over the answers on the smart board. She then handed them a worksheet that the students were to fill out after completing the activity. She assigned three students to each group. In the back of the room, she had seven different papers with shapes on them, two pyramids, two cylinders, two cones, and one prism. For each group, Ms. James selected a leader to pick up four shapes. After each student in the group completed a shape, they explained their findings to the other members and all the members filled out their worksheets. Everyone in the group worked together on the fourth shape, the prism. During the session, the teacher continuously walked around the room answering questions and monitoring the groups’ progress. At one point, she interjected, “You’re going to use a different formula for each one." Everyone in the class finished the worksheet and handed it in at the end of the period.

Brain/mind principles suggest providing students' choice and flexibility to enhance learning. In this lesson, Ms. James chose the group and group leaders, and there were specific outcomes for the shape calculations. However, this learning experience also demonstrated some behaviors reflected in the brain/mind principles. Among these were: small group interaction where students were allowed time to construct their own learning with a hands-on activity; time to process information by explaining their results to the other students in their group; application where students worked with concrete examples of the concept; feedback from the teacher and their peers; and opportunities to practice the procedures with several math problems before doing the hands-on activity, which is important for mastery.

Through doing activities, Ms. James hopes that students will grasp the concepts rather than just memorize the procedures. "Like in yesterday's lesson, actually to understand where the lateral area comes from and how the formula actually works, they can see it 3D (three dimensional)." She admitted that sometimes it is necessary for students to engage in practice and drills to improve comprehension, however, it is also critical for students to understand how these concepts are used in real life applications. "We do little mini projects throughout the year, like one time they had to design a room and so they actually had to use measurements and size and architects and blueprints and that kind of stuff."

Next year, she said, she will be using a product called Math Navigator, introduced by the school district to engage students and reinforce the basic concepts with hands-on activities. Two of the modules are used for lower level math students like those in conceptual math, and two modules are designed for Algebra 1 and 2. “You go over less stuff, but you have more time to understand the basic concepts.” She added that this program will work out well with the block schedule that will begin next year, which reduces the time spent in each period from one hour every day to one and a half hours every other day.

A few of the challenges to teaching for Ms. James is keeping the students motivated and engaged with their learning. Sometimes she uses games to reinforce math skills. “Like we use flash cards around the world so they are doing their basic math facts, but they think it’s a game.”

Student collaboration is another challenge because some students are not well disciplined. “It’s great when both kids are hard workers, but there’s too many times when one kid hasn’t done anything and another kid has done everything.” She feels that if she were better with classroom management, she could incorporate more collaboration because she believes that it does facilitate learning. ”When one student can explain something to another student, they’ve mastered it.” Also, she pointed out that students are more receptive to one another than they are to her.

She emphasized that collaborating with colleagues is “immensely” helpful to her teaching. “The math department is just amazing here.” She said that she gathers ideas from other teachers who have more experience. “If I have a question about a project that they've already done they can tell me what does and doesn't work." She added that if she's confused as to how to teach something, they offer a better way to explain it.

On the survey, Ms. James' perceptions of using brain-based practices were inconsistent with the behaviors demonstrated in the classroom. On the survey, she indicated that she "never" helps students understand the concept before breaking it into parts. However, during the classroom observation, she used several examples in explaining different shapes to her students to help them understand the concept before having them work with the shapes and make calculations.

Also inconsistent was Ms. James' perception on the survey that she "never" allows time for students to process information, but "sometimes" allows time for students to apply learning. During the classroom observation, students were given time to gain deeper understandings as they worked together in groups calculating the lateral area of shapes and explaining their findings to the other members. As recommended in the brain/mind principles, providing instruction that moves beyond merely memorizing facts allows students time to apply information, and facilitates the growing and connecting of students' brain structures for more efficient processing.

Mr. Story (Survey 20, Rubric 70)

Mr. Story, who has taught school for 28 years, has a masters degree and is nationally board certified. He currently teaches 11th grade U.S. History in the integrated American Character course, and one separate 11th grade U.S. History class. On the survey, Mr. Story indicated that he "frequently" uses eight of the brain/mind principles, and "sometimes" uses four of the principles. The four principles were: students assess their own learning; students have time to process; students pursue their own interests; and students have opportunities to construct their own learning.

On the day of the observation, the classroom had six straight rows of six desks facing the front of the room. Dream catchers, created by the students, hung from the ceiling, and maps and posters of political figures and popular celebrities from the 1960's, i.e., The Beatles, covered the walls. Also, on the walls, were the pictures of all the students in the American Character classes.

Just prior to the 4th period class, some students sat in the classroom during lunchtime, eating and chatting with Mr. Story. When class began, Mr. Story instructed the students, 36 in attendance, to identify key people of the 1950's and 60's as he presented a Power Point on the overhead projector. As each picture was shown, students wrote down the name of the individual on a piece of paper. Mr. Story gave them clues connecting the figures to key events that occurred. After they finished, students were called on to give the answers.

The students were then asked to pull out their notes from the previous day. In a power point presentation, Mr. Story reviewed some of the information that they had about Viet Nam and then proceeded to talk about the 1960's Free Speech Movement in Berkley. He highlighted the critical information to include in their notebooks, and reminded students that today's information will be included on tomorrow's notebook exam. (They are allowed to use their notes when taking the test.)

During the Power Point presentation, Mr. Story explained that because of the increase in college enrollments at Berkley, students were feeling a loss of identity, which gave rise to student activism. One of the leading activists was Mario Savio. Mr. Story said, “Just write his name with the Berkley Freedom of Speech Movement.”

After he finished the presentation, he showed a video of actual footage of the events that occurred in Berkley. The video was shown on two TV sets in the corners in the front of the room, and on the overhead screen. Students did not take notes during the film.

After the video, which lasted 20 minutes, Mr. Story said, “Now, pay attention to this. We’ll see how smart you are.” Mr. Story showed a short video clip of a magic act and asked the students to take a few moments to figure it out. (Mr. Story says that he sometimes interjects brain twisters to rejuvenate the students when he sees them “nodding off.”) After a few moments, Mr. Story moved on with the lesson without giving them the solution to the problem. With 10 minutes left, he asked the students to share the information they each read yesterday from the textbooks (students were assigned different readings in their groups) and to complete their worksheets.

This lesson offered few opportunities for the students to construct learning as recommended by the brain/mind principles. The teacher disseminated the information, specified which notes to take, and had the students fill in their worksheets with the information pulled directly from the textbooks. However, some brain/mind principles were demonstrated: the teacher directed the students’ focus by clearly articulating the lesson objective; he was knowledgeable about the subject, Freedom of Speech

Movement, and helped the students understand the details surrounding that event; he used video clips to reinforce the material presented; and at the end of the period, students worked together to share their answers for the worksheet. In addition, a brain twister was introduced as a tool to rejuvenate the students' attention, especially those who were beginning to "nod off."

Mr. Story, who helped develop the American Character course 10 years ago, believes that the difference between the integrated course and the separate discipline is the idea of building community and putting the student first. "We not only connect with their emotions in the projects that we develop, whether it's going somewhere, or doing cookouts or dream catchers (during the western unit), but it also allows a social environment where they can interact academically." Offering a social context where students can connect information emotionally and intellectually, he said, impacts long term meaning. "So culminating events help the student to see the context in a broader way and to have that emotional connection as a community, not just a unit test where you just move on to the next one, but in some way, allow time to celebrate that unit."

When he teaches history as a separate discipline, it's more "compartmentalized and sterile." "It's more like an assembly-line box. Here it is, boom, you know, you're out of here in 55 minutes." Although, he said, that the integrated course may look like the separate course, if seen in its entirety, there is a synergy that exists in the integrated course with the students, the two teachers, and the curriculum that connects it all together. For example, he said, near the beginning of school we take a field trip to the Veterans Cemetery (which is located 5 miles from the school.) Students take large pieces of butcher paper, lay them flat on a gravestone and with charcoal trace the information on the gravestones to the sheets. When students return to the classroom, they select one of the grave markers and research that period of time, picking out three to five historical events, and incorporating those events to create a graphic story about the person. By writing a short historical fiction, students can explore the power of language to create a mosaic of the human experience that history has shaped through certain events.

Mr. Story says that the course has changed over the years. With the EOC exams driving the curriculum for history, the challenge for him is keeping up with the other History classes and covering all the required material. In order to make the adjustment and still allow time for the projects and field trips, some of the topics for English have been eliminated, and some of the topics studied in the history class are skimmed over. Amidst the challenges of providing students the necessary information for passing the EOC exams, Mr. Story's primary concern is that "students walk out of here knowing they had a wonderful opportunity to learn in a fashion that I think is far better than other teachers around here."

By including projects and field trips, students in the integrated American Character class are given opportunities for more contextual learning, that is, learning which cuts through traditional curricular boundaries and weaves together subjects and skills that are naturally found in life. Brain/mind principles recommend that interdisciplinary and cross-disciplinary models helps students see ideas in relation to each other as well as how individual facts become meaningful in a larger field of information. However, on the day of the observation, Mr. Story used a similar approach to teaching as

Mr. Cooper, another 11th grade History teacher in the study. He introduced the subject, broke it down into details using analogies and explanations, and used a power point presentation, video and textbooks to enhance comprehension and retention. There was very little student involvement aside from writing notes when directed to do so, and completing their worksheets with literal information from the textbook.

Mr. Farley (Survey 21, Rubric 66)

Mr. Farley teaches 12th grade Wildlife and 12th grade Anatomy. He has been teaching for nine years and has a bachelor's degree in forestry and wildlife with endorsements in social sciences and humanities. On the survey, he marked that he “frequently’ used nine brain/mind principles. However, on three principles he noted “sometimes.” The three principles were: students assess their own learning; the teacher uses multiple forms of assessment; and students have opportunities to construct their own learning.

The observation took place in his 5th period wildlife class with 27 students in attendance. Like the other science classrooms, there are three rows of four tables facing the front of the room. This room also displays posters on the walls that students created as part of a science project.

When class began, most of the students were standing in anticipation of going outside and playing “Musk Ox Maneuvers,” a game devised by Mr. Farley where six of the students assume the role of wolf and the rest of the class are oxen. The oxen wear a belt around their waists with a flag, like in flag football. Before the students go outside, Mr. Farley announced, “Limit the tripping.” “Yeah,” said one of the girls, “This class is pretty intense.”

The students gathered on a grassy area outside and huddled together in a pack while the wolves split up and attempted to grab the student’s flag. Some of the oxen tried to elude their aggressor by running away, but the wolves always managed to catch up and wrestle the flag from their belts before the teacher blew the whistle to stop the game. ”Can we play five more minutes?” the students asked. They all seem to be enjoying themselves. The teacher consented and the students traded off playing the role of wolf. After a few more games the teacher and the students returned to the classroom.

While in the classroom, the students took their seats and Mr. Farley said that before they “get their story,” the students will do a behavioral experiment with one of their peers. After that, they’ll finish the worksheet on animal behavior that they began yesterday. (Mr. Farley, who was a biologist, tells the students stories about his wild experiences when he was studying bears.)

Before the experiment, he discussed the similarity between human behavior and animal behavior and explained how nature and nurture influence behavior patterns. “How animals and humans react to a situation can be a reflex behavior that is born into you, or can be learned from the environment.” He then explained animals and humans’ “fight or flight” survival instinct when confronted with a dangerous situation.

Mr. Farley then asked students to select a partner. One student wears goggles and the other student records his/her reaction after throwing a Styrofoam ball at the student’s face. The students then switched roles and discussed with their partners what they observed about their reactions. The idea, Mr. Farley told them, is to monitor a student's reflex reaction. Most of the students finished in 10 minutes and got a textbook to complete the worksheet. There was one table with eight students huddled around it who used the entire class period throwing Styrofoam balls at each other and giggling. They never completed the assignment. At one point Mr. Farley interjected, "Remember guys, you want to finish the assignment." Near the end of class, some of the students asked, "What about the story?" and Mr. Farley replied, "There's not enough time now." Most of the students looked disappointed.

In this lesson, the simulated activity, the Musk Ox Maneuver game, and the experiment, provided students an opportunity for collaboration. As recommended in the brain/mind principles, student collaboration builds camaraderie and helps to expand students' thinking. However, there was no time allowed for discussion about students' reactions to the Musk Ox game or the experiment and its possible implications about animal behavior. Also, it was noted that eight of the students chose not to do their worksheet assignment even though this was one of the lesson objectives.

Mr. Farley said that this time of year when you have a few weeks left of school, it's hard to keep students focused. He said that upperclassmen (juniors and seniors) have a lot more freedom than underclassmen (freshman and sophomores), who require more discipline. However, he does require that all students adhere to the due dates for assignments.

The Wildlife class is modeled after his own experience researching bears in Northern New Mexico and Virginia for Hornocker Wildlife Research Institute. "The class is atypical in terms of there's a lot of outdoor activity but there's also a lot of traditional lecture and worksheets as well." The students are required to keep journals describing their wildlife observations, which include identifying the species, observing the animal's behavior, and watching its interactions with other animals. Every two weeks the students hand in their logs with journal entries reflecting two hours of observations in school and two hours of observations outside of school.

The lectures incorporate discussions on individual species, physical characteristics, and behavioral characteristics. "We learned about what they do, why they do what they do, and how they survive. Now we're looking at behavior and population dynamics."

He said that in order to keep students focused in class he doesn't talk more than 15 to 20 minutes at a time. "Then usually they'll have a worksheet that goes along with the lecture or an activity." He also finds that getting the students outside helps with classroom management issues.

However, next year students will have less time allotted for outdoor activities because the wildlife class will have a set curriculum aligned with an EOC exam.

> Anytime you have an EOC, you have to teach to the test in some form or another, and it will limit the amount of research we can do. For example, they won't be able to do as much bird identification outdoors. (Interview—05/18/09)

Currently, the wildlife class has more flexibility than his anatomy class, which adheres to a rigid set of standards. "The direction we go for discussion or lecture is a lot more varied in that if the students are interested in something then I have more time to go off on that tangent." Also with a flexible schedule, students have more time to get outdoors. "A lot of these kids spend a lot of time inside in front of computers. So to appreciate where they live and their surroundings is an important aspect of education."

Mr. Farley believes that students need time to process information and make connections. However, issues relating to standardized tests, curriculum standards and time constraints, limit the teachers' instructional options, particularly in terms of brain-based teaching strategies. Adhering to a rigid curriculum narrows the focus of learning to more prescribed outcomes allowing less time for students to build connections and understandings in a more authentic environment. Unlike this restrictive atmosphere, Mr. Farley's wildlife class, allows students an opportunity to get out in the field and observe animals in their natural habitat. Students keep logs and reflect on their observations, analyze data and make predictions. Mr. Farley feels that the flexible format provided in this class allows students time to interact with the outdoors, while pursuing their own inquiries during class discussions.

Contrary to his view of student interaction were the behaviors demonstrated in the classroom observation. Although students did get outdoors, time was not allotted for students' inquiries. There were no opportunities for class discussion or feedback, which was inconsistent with Mr. Farley's claim on the survey that students "frequently" have time to process information. In order for students to strengthen and build neurological pathways, the brain/mind principles emphasize that students be allowed time to exchange thoughts and information with others to challenge ideas and patterns of thinking. Without this component included in the lesson, students' learning is not reinforced or challenged.

Also. there was a contradiction between Mr. Farley's perception and his behavior regarding the lesson's objective. Mr. Farley stressed in the interview that upperclassmen (juniors and seniors) have a lot more freedom than underclassmen (freshman and sophomores), who require more discipline. However, he does require that all students adhere to the due dates for assignments. This requirement was not reflected in this lesson. The students, comprised of 12th graders, were supposed to finish the worksheet by the end of the period, yet eight students made no attempt at doing it, and none of the students handed it in.

Ms. Jolly (Survey 21, Rubric 45)

The next teacher in the study, Ms. Jolly, has a bachelor's degree and has taught for 11 years. She is certified to teach social studies, speech and debate. On her survey, she acknowledged that she "frequently" uses nine of the brain/mind principles and "sometimes" uses three of the principles. Those three principles state: students assess their own learning; help students pursue their own interests; and provide students a multi-sensory environment.

In her 10th grade History class, they were reviewing for a test to be given the next day on manifest destiny and the westward expansion of the United States. After the bell rang for class, students milled around. Some students were talking with one another, and others were shooting a Styrofoam ball into a basketball hoop positioned in the back of the room. (She says later during the interview, that students elected to allow five minutes for free time before class starts.) Class began five minutes later and the students took their seats. There were six rows of desks facing the white board where the teacher had drawn a chronological sequence of pictures depicting a series of events beginning in 1830 with the “Indian Removal Act,” which forced the Cherokee people off their land in Georgia to Oklahoma. Pictures are well-designed and the writing beneath them is easy to decipher.

The classroom has several pictures of presidents, historical events, and flags of different states on the walls. The teacher informed the students that they will need to bring their own colored pencils for tomorrow’s test to color in a map of trails leading west, and told them that, in addition to the map, there will be 75 multiple choice questions on the test. She then directed the students’ attention to the overhead and told them to take out two sheets of paper. Students were called upon to read information from a transparency, which was written in small lettering. One of the students said, “I don’t know. I can’t even read that.” So she moved on to another student. Some students were able to read the transparency, but others claimed to have difficulty reading it. None of the students was taking notes. After going over the notes on the overhead, she referred to the pictures on the white board and said, “Now, you need to take notes.” Students began taking notes as she referred to each of the pictures and pointed out the key events and what they needed to write down. After reviewing this information, students used the rest of the period, 30 minutes, to study for tomorrow’s test on their own or with a partner.

Aside from presenting some of the information in a pictorial sequence, which according to the brain/mind principles helps students to reinforce concepts, and allowing students some time to review for the test, the lesson was mostly devoid of brain-based principles. Overhead slides were difficult to read and the students were not participating in the review with the teacher, aside from reading overhead transparencies, which many of them couldn't decipher.

Ms. Jolly's perception of teaching is to embrace as many of the senses as possible during a lesson. "If you're just handing them a paper and a pencil, it won't work for a media-hyped generation." So, she said, for example, "If we're talking about corn in Jamestown, we're going to eat corn products." And, every week she puts a timeline on the white board. Occasionally, she asks students to use large white expo storyboards to draw their own pictures. "I learned in college that if you draw, you retain the information."

Also, in order to enhance comprehension and retention, Ms. Jolly said that she strives to make the textbook information relevant to the students, "bringing it to life." She emphasized that a teacher has to be creative and use life experiences to help students connect their knowledge with the material; otherwise, they won't understand what is happening in our society.

For example, on the day of the interview during her lunch break, the desks in her classroom were turned upside down. She explained that in her classroom students are learning about the process of compromise, consensus, conflict, and war. The upside down desks reflects the confusion that happens in war, so she says that when the students enter the room 4^{th} hour they'll have to spend some time getting their desks back in order before starting class.

Every week, she said, she tries to create an "experience" to help her students learn because "if you show me and we do it together I'll retain it, as opposed to going traditional school." Referring to the westward movement, Ms. Jolly said that instead of using maps to illustrate the movement, she had the students push the desks aside and bring in dominoes and toy railroad tracks from home. The dominoes were used to represent the trails west, and the railroad tracks were used to represent the east coast line.

For students with difficulty retaining information, she uses some other sources to help him/her. For example, if a student says the primary export for Jamestown was corn when the answer is tobacco, she may hold up a plastic manipulative of tobacco so that the student sees as well as hears the information.

When asked about how she proceeds in teaching a lesson, she responded that yesterday's lesson, the one used for the classroom observation, was typical of what she does. She pulled out a big white binder and said, "What I have is right here. Here is Chapter 4-6 out of the textbook and here are all the assignments and keys made up." She said that she's fairly traditional. Each day she tries to do a different activity. For example, on Monday they drew storyboards. On Tuesday, they read the textbooks. On Wednesday, they sat around in a circle and discussed their research on Andrew Jackson. On Thursday, she reviewed for the test, and on Friday, students take the test.

Each student has a scoreboard of the assignments for the nine weeks and keeps track of their progress in the class. The emphasis is to empower students to govern themselves. She says the class motto is: "Read, think and make your own decisions so we may seek truth and liberty and justice for all."

In the interview, Ms. Jolly noted two essential ingredients for education: that in order for students to learn they must be actively involved in the learning process, and that the goal for studying history is to promote self-governing individuals who can think for themselves. She maintained that it's important to bring the curriculum to life so that students can experience learning and understand what's happening in our society. She feels that teachers need to go beyond 'paper and pencil" methods to reach students who are part of a media-hyped generation. Yet, she demonstrated some behaviors that were inconsistent with her perceptions for encouraging students to think on their own.

Her lesson, which she says is typical, contradicted her nontraditional philosophy. During the classroom observation, Ms. Jolly demonstrated a stand and deliver approach dictating what information the students should write down. In addition, students were asked to read transparencies on the overhead, which some students referred to as illegible. There were no opportunities for students to construct their own learning.

Learner-centered environments, as recommended in the brain/mind principles, emphasize learning as a process of exploration where the student is challenged to seek patterns and solve problems through logical thinking and creativity. Although Ms. Jolly indicated on the survey that she "frequently" allows students opportunities to construct their own learning, the classroom observation showed students tasked to give one correct answer to teacher directed questions. And, although students were allowed time to study for the test together or alone, there were no opportunities for critical thinking. Students prepared for an objective test, comprised of 75 multiple-choice questions.

<u>Mr. Moore (Survey 22, Rubric 48)</u>

Mr. Moore, who has taught for 7 years and has a bachelors degree in English, teaches 9th grade English. On the survey, Mr. Moore indicated that he “frequently” used brain-based strategies on all but two principles. He marked “sometimes” for the principle which states, “students assess their own learning,” and he marked “sometimes” for “students are provided a multi-sensory environment. “

The day of the observation, he began by showing the list of class assignments thus far in the semester on the overhead screen. The teacher requires that the students keep a notebook with all their assignments. As students checked their notebooks, jazz music plays softly in the background. Mr. Moore interjected, “I’m not going to answer ‘what page is this on?’ Look it up in your table of contents.”

This class consisted of 37 students. The desks are all occupied. Three rows of desks faced the front of the room, and five rows of desks were on the side facing the three rows of desks. Some pictures of authors and books were on the wall and a bookshelf contained a few books and some dictionaries.

Mr. Moore turned off the music. He talked a little bit about challenges and then posed the question, “Have you ever felt like life was a constant struggle?” Students did not respond. He related some more examples and then asked them to address their own personal experience in their journals. As the students wrote, he played music in the background. After 10 minutes of writing in their journals, Mr. Moore stood in the back of the room and directed their attention to a power point presentation on the overhead. He told them what to write down in their notes about sound devices used in poetry and he gave them examples of end punctuation, rhyme and rhythm.

Mr. Moore then asked for volunteers to read the poem, “Uphill.” Four students raised their hands and he remarked, “I always get the same people.” So, he drew four names randomly from a pile. Students sat quietly while names were read. The students who were selected read aloud while the others were to follow along. Upon completion, the teacher explained the symbolism and the rhyme scheme. He then assigned page 814 in the textbook, which required students to work on some critical thinking questions. After five minutes, he called on students to answer the questions. Near the end of class, he assigned the students to write a poem similar to the rhyme scheme of the poem they read in class.

The brain/mind principles demonstrated in this lesson were: the interactive notebooks where students were responsible for organizing past assignments and keeping track of their progress; journal writing to allow students to think about their own challenges in life before reading the poem; using stories to help the students understand the concept; and breaking parts of the poem down to explain its meaning. Students were also given an opportunity to consolidate and apply their learning by writing a poem about the challenges in their own life. Although the lesson was well structured according to the brain/mind principles, the lesson allowed no opportunity for students to discuss or share their journal writing, or to give their own interpretations of the poem.

When addressing this issue of class discussions, Mr. Moore, who taught an integrated history/English class in San Diego on a two hour block schedule, used to allow a lot more time for this activity. “Now going into the 60 minute class, I’m getting used to not talking so much and getting them to work.” In addition, the large class loads make it difficult for student interaction. So instead of using time for discussions, he has the students write in their journals to help them make their own personal connections to the subject. He is a strong advocate for writing and loves to write. “So my favorite thing is getting the kids into writing, creating their own stories and poems, kind of finding their voice.” He mentioned that many students are uncomfortable sharing their writing, and he would like them to feel more engaged.

Ultimately, Mr. Moore wants to provide an atmosphere of learning where students are challenged to think for themselves. “I like them to figure things out and arrive at some answers themselves. I like them to get involved in their own learning.”

In addition to motivating students to get more involved, Mr. Moore would also like to see them take more responsibility. As a struggling high school student himself enrolled in AVID (Advancement Via Individual Determination), a program to help underachieving high school students prepare for and succeed at college, he was introduced to the interactive notebook to help him stay organized. “Some kids really struggle with this and I don’t want to hurt them because I do count it as part of their grade, but many of them don’t know how to take responsibility and this is one way to help them.”

Another way Mr. Moore encourages responsibility is by having students read their class novels at home. He said that because of time constraints, he’d rather have the students use their time in school for writing or discussions. “A lot of times if I assign work, they won't do it at home." He said that he knows which students read at home because he always starts out with a question of the day that pertains to the reading and they have to write about it in their journals. "Kids are pretty honest these days. They usually tell me if they haven't done it." However, he also recognizes that many students do not like to read so he tries to give them a choice. When they created their own historical narratives, he allowed them to choose their own books among 15 novels. "I think that will help engage their interest more."

There are no common assessments for English in the district so he said that it's not necessary to rush through material to keep up with other classes or to cover certain material that will be on the test. "It's so broad that you can teach just about anything across the spectrum, so you can pick and choose what you feel kids will connect with."

Mr. Moore assesses their learning by using "lots of quizzes." He also issues a unit test, mostly comprised of multiple choice questions and short essays. He mentioned that he uses multiple choice questions because the standardized tests are designed that way and he wants students to succeed.

Data from the interview, the observation and the survey, revealed inconsistencies between Mr. Moore's perceptions of using brain-based strategies and his behaviors in the classroom. Mr. Moore indicated in his interview that he wants students to "find their own voice" and feel comfortable sharing their ideas with their peers. This perception was also reflected on his survey where he indicated that he frequently uses strategies to facilitate a student-centered learning environment where students are encouraged to reflect and explore their thinking. He noted that he "frequently" provides opportunities for students to interact and discuss ideas. In actuality, this did not occur during the classroom observation. Only four students, who Mr. Moore acknowledged always volunteer, were willing to participate. So, in order to solicit a broader range of student participation, he selected students to answer the teacher and textbook guided questions.

In addition, although the brain/mind principles emphasize that time be allotted for students to actively process information and construct their own learning, Mr. Moore admits that because of having only 60 minutes, there isn't enough time for class discussions. Even though he stressed that there are no common assessments for English so it's not necessary to rush through material, the students were not allowed time to share their thoughts in the reflection journals or discuss their interpretations of the poem read in class. Instead, Mr. Moore dominated the session with his interpretations.

Themes

While many of the teachers' responses to the surveys and interview questions indicated a commitment to brain-based strategies, the data revealed a strong tendency toward teacher-centered instruction aimed at fulfilling strict curriculum guidelines aligned with measurable administrative objectives. Rather than teach a personally challenging curriculum that strengthens and develops pathways in the brain, teachers expressed frustration over state standards that made them accountable for "teaching to the test." As Mr. Cooper, the 11th grade U.S. History teacher, suspects, most educators like himself "are swimming around in the shallow end of the Bloom's pool" just barely skimming the surface of student learning.

In the following discussion, two themes emerged from the data that may explain possible limitations affecting teachers' perceptions of using brain-based strategies with behaviors demonstrated in the classroom. As already mentioned, the themes include: time constraints due to covering the curriculum and preparing for standardized tests; and issues dealing with students' lack of motivation, self-discipline, skills and/or aptitude, as well as administrative pressure that could affect student accountability.

Time Constraints

Allowing students time to process and learn is an integral part of Caines' student-centered model. Students need time to think about their experiences by reviewing what happened, applying what they learned, and expressing these reflections in journals. However, in this study, teachers expressed concern that time constraints in covering the material conflicted with time allowed for students to process information and reflect on their learning. Mr. Cooper (Survey 15, Rubric 61), for example, who has taught for 11 years, and has a bachelors degree in political science and speech, agrees that students need time to process information. But, using time for class discussions or projects isn't realistic "when the clock is constantly ticking, breathing down my neck." He understands the administration's concern about aligning the curriculum and keeping teachers accountable, but what is lost are the "real cool ideas" that you may want to use to reinforce learning.

Before the EOC exams became a requirement, he had more time for projects and simulations. For example, while studying the industrial revolution, Mr. Cooper would recreate a factory in his room and the students would work on an assembly line. To invoke realism, he would play tapes of loud factory noises, like hammers chisels, saws and grinders and turn the temperature down or up to make it as uncomfortable as possible. After completing the simulation, he then had students write down how it felt to work in Cooper's Factory.

But, because of time constraints in covering the curriculum, he has moved away from many of these activities and experiences that promote critical thinking and deeper understandings. Having to teach to the test contradicts his belief that the process of learning is more important than the final product. He often tells his students, "The doing is more important than the done." He would like students to be engaged in the material and involved with searching for answers to their own questions. "So when I see two kids together debating over something that's going on in class, I say, 'teacher wins,' because they're actually thinking about the material." However, he admits that most of the work students do in his class is worksheets and tests leaving very little time for student interaction or opportunities to construct their own learning,

Mr. Schwartz (Survey 15, Rubric 60) also teaches an 11th grade U.S History class. He laments that because of the EOC exams, he has less time to help students personally connect with the subject and it "ruins my fun and enjoyment of teaching history." Mr. Schwartz, who has taught for 16 years, and has a bachelor's degree in political science and history, explains, "The more I deal with the EOC's, the worse my class gets because I have to deal with little factoids that really don't hold their interest nor will they really ever need to know." He said the test is not 'overly difficult" to pass. He could give them a study guide for two weeks and they could pass the test, but they get no understanding of the bigger picture, or how events relate to each other. “They have no personal ownership, no clue about anything in American history or how it connects to their own lives.” Mr. Schwartz adds that the main goal for students in history class is to understand what it means to be an American. “Who cares if they can list 25 presidents?”

Ms. Vincent (Survey 16, Rubric, 77), who teaches 9th grade Honors Earth Science, and has a masters degree, says that her teaching has changed over the past 24 years in that, she, too, is teaching more to the test. Unlike the past, where she spent more time in helping students make deeper connections, she finds now that it is necessary to concentrate more heavily on memory techniques.

Although standardized tests keep the schools accountable, she feels that they are not accurate indicators of a student’s general knowledge base, but rather, focus excessively on the ‘little nit picky details.” Some of the questions are extremely specific and what’s hard about it is that you’re testing them (the students) over three years, 8th, 9th and 10th grades.” (Students take the ISAT, Idaho Standardized Achievement Test, in the Spring of their sophomore year.)

In addition, she says that the earth science standards were written by a group of biology teachers so there are two facts in the standards that are incorrect. “I think we need to fix our standards first before we can create a test that truly measures.”

She believes that if the curriculum was pared down to eight concepts, students would have a deeper understanding of science and be able to think and process information better. However, she says, “We’re not looking at the big picture anymore.

We have gone away from critical thinking, which is wrong, to more content. So we have to make sure that they (students) do get the little details."

Unfortunately, with the block schedule next year, where classes meet for 90 minutes every other day, there will be 20 percent less class time to cover the same content. Ms. Vincent also anticipates more time spent on reviewing the material from the previous class. "This is a backwards step like no other for our kids. We are truly going to be teaching to the test because there's no other option."

Mr. Reese (Survey 15, Rubric 51), who also teaches 9th grade Earth Science as well as 11th/12th grade Ecology, however, feels differently than Ms. Vincent. Mr. Reese is in his third year of teaching and is working on a masters degree in science. He believes that the 90-minute block schedule will allow time to cover a topic more efficiently than the 60-minute class. It will force teachers to trim the curriculum and "will change things from being strictly fact based to more concept driven." He acknowledges that the challenge will be to reduce the curriculum and still meet the requirements of the EOC exams. However, by eliminating areas of redundancy a "leaner curriculum" could be created. He believes that the 90-minute block schedule will provide an opportunity to teach students how to make deeper connections and apply learning.

> When we close the segment for the day, we'll get some sort of feedback (discussion, quiz or an activity) knowing the kids actually learned something more than just we hit some top facts and the next day we have to reintroduce the same facts knowing the kids probably forgot half of what you talked about. (Interview—05/14/09)

Student Issues

Brain/mind principles stress that sufficient time is necessary for effective processing and restructuring of the brain's patterning. In addition to time, students need opportunities to initiate their own learning in order to make deeper connections and apply what is learned. Thus, the teacher provides many opportunities to engage students' interests and deepen their thinking.

In this study, teachers acknowledged the importance of empowering students to take charge of their own learning. However, patterns and themes that emerged from the data suggest extraneous variables that could limit the teacher's ability or willingness to use brain-based strategies in the classroom. These variables included: student's lack of motivation; self-discipline; skills and/or aptitude; and accountability.

Ms. Tripp, the French teacher (Survey 19, Rubric 72), says that her greatest challenge is motivating students who are disinterested in learning French. She has learned that students are more responsive when they generate their own ideas, like the time they were studying the customs and language in Morocco. Students decided to bring in music, food and a variety of teas from that country. However, she said, "The downside to that is when we try something and they aren't responsive at all." This was evident the day of the observation where Ms. Tripp selected students to participate in a "fashion show." She thought this lesson was effective because she believed it was relevant. "Even the most uninterested student cares about what they look like and many of them are aware that the fashion comes from France." But, during the lesson, most students appeared uncomfortable with going up in front of the room as the teacher introduced French terms for the articles of clothing that they were wearing. And, students appeared to be losing their focus as Ms. Tripp, acknowledging their disinterest, said, “We’re almost done.”

The brain/mind principles emphasize an environment that allows students to choose areas of interest as well as to collaborate with one another in order to cultivate an atmosphere that is pleasant and emotionally uplifting. Although the French lesson required repetition, which is important for mastery, it lacked student engagement. Lessons that involve student interaction and collaboration are effective in helping students construct and reinforce learning. Ms. Tripp, who’s taught for 25 years and has a masters degree in curriculum and instruction, maintains that student collaboration is heavily emphasized in French class. “They do partner exercises for vocabulary and grammar.” And, sometimes, after she’s explained a grammar concept, she’ll say, “Partner on the right, teach that concept to partner on the left. If they can explain it then they understand it.” But, despite her efforts, she feels students are apathetic and unfortunately this attitude is supported by the counselors at the school who have mentioned to her that French is unimportant since it is not a major language.

Ms. Jewel, the Latin teacher (Survey 15, Rubric 86), also sees a lack of motivation and self-discipline with students. Generally, students take Latin, she said, to improve their skills with the English language, build their vocabulary, and increase their scores on the SAT. “Latin students score between 50 to 75 points higher than other students because they have the vocabulary and basic root words.”

But, although Latin can be beneficial, she said, she has seen a decline in students’ work ethics and a drop in the EOC exam scores over the past three to four years. Ms.

Jewel, who has a bachelors degree and teaches Latin and 10th grade U.S. History, says that students aren't willing to work as hard and stay on top of the grammar rules and vocabulary essential in mastering the language. Students lose incentive when they realize that they're not getting the grade they expect. Disillusioned, they drop the course.

She feels that students and perhaps parents too, have lost sight of what education should be and the benefits derived from pushing students beyond their self-made limits in order to optimize learning. She remembered having two deaf students and another student who was on an IEP (Individualized Education Program) in her Latin classes. They all succeeded. The student on the IEP struggled with writing and spelling in English, but she held him accountable for his spelling in Latin. "It was a signal to me that sometimes we have these accommodations for students, but when you really make them do it, they can. They find the accommodations within themselves to overcome those trouble spots."

She believes that learning from adversity and challenges, helps students prepare for life. However, she says, it's increasingly evident in students coming into high school from middle school that they don't have the study skills and discipline it takes to be successful. "They think, well you know, I can let this slide this week and I'll catch up next week. But then they're in a constant catch up and they get further and further behind." Ms. Jewel, who's taught for 10 years, says that this year, she's had to do a lot more work with translations than she would normally do just to reverse the downward curve on the EOC exams.

Ms. Mason (Survey 14, Rubric 82), one of the two mathematics teachers in the study, agrees that students lack skills and self-discipline, which places greater pressure on her to insure students' success on the EOC exams. In fact, three times during the classroom observation, Ms. Mason mentioned to the students, "This will be on the test." During the interview, she explained that because the emphasis is on standardized test scores in the district, there is little time to deal with concepts in depth. Students often ask her how they are going to use some of the math theories in real life. Without real life application, she said, "They don't know why they're doing something."

At her former school in L.A., she said that the curriculum focused more on the student's construction of learning and application of concepts. Students were applying math to real life situations, rather than just memorizing procedures to pass a standardized test. Unlike the students at the school in L.A., she said that students here have a difficult time understanding concepts, or trying to figure out problems on their own. For example, she explained that when she introduces factoring to students she tells them that it is used to figure out the area of a triangle. "My kids, I left them in the dust when I started talking about that. They understand procedures and they're waiting for me to say, 'okay, this is how you do it.'"

Ms. Mason, who has an understanding of brain/based teaching, gets her ideas from "constantly" attending conferences and classes. "It goes back to my first years teaching. My department was actively involved that way." She's noticed, however, that none of her colleagues at this school attends any conferences even though she encourages them to do so. On her self-assessment survey, her perception of teaching brain-based strategies was lower than the average score of 16. Because the district and school support a curriculum that is more teacher-directed rather than student-centered, she feels that she is just barely touching the surface of student learning.

Ms. Mason, who has taught for 17 years and has a bachelors degree, teaches Algebra 1 and Math Analysis. She tries to incorporate lessons that require critical thinking, like giving her Algebra 1 students a problem where they select four numbers and create 10 problems using four operations: addition, subtraction, multiplication, and division. The solutions number 1 through 10 and the students have to explain how they arrived at their answers. “They actually have to write about it and they fight it. So again, they don’t like being in my class because the other math teachers aren’t doing that.” A student-centered curriculum, she says, requires letting go of the control and is more time consuming.

Mr. Bixby, 11^{th} grade English teacher (Survey 13, Rubric 68), finds it difficult to let go of the control. “It’s hard to do three books; each kid reads their own book and to keep up with that.” Although, he realizes that allowing students choices in selecting their own novels makes a difference in comprehension and success on a test, he finds that it presents problems. When students get in their reading groups, they have a tendency to socialize and not talk about the book. “So I find the books that I pick, obviously the ones that I like, that I feel they’ll get something from, so I’ve pretty much taken the choice away from them.”

Mr. Bixby’s taught for 33 years, and has a bachelors degree in physical education and a minor in English. He says that the main challenge for him is motivating students to read at home. He gives them some time in class, but they are responsible for completing the reading and having their study guide questions filled out the next day. “The problem is that they don’t do anything outside of class so then I end up pretty much giving them the answers and they write it down on their study guides. So, yeah, I’m doing all the work.”

Mr. Schwartz (Survey 15, Rubric 60), the 11th grade U.S. History teacher, also contends that students lack motivation. He said that because there are more AP and honors classes offered now, he’s losing the “good kids.” He explained that the honors kids were the ones who invigorated class discussions or answered questions that would encourage other students to participate. He said that it’s difficult to have a classroom discussion with students who are apathetic; “To try to actually pull some things out of them where they actually speak to you.” The day of the observation, this perception was evident. Although Mr. Schwartz was asking questions to promote interaction with the students and stimulate critical thinking, students were unresponsive.

Mr. Schwartz wants students to develop skills. “What I hope they gain are some cognitive skills, like reading maps and reading, just basic skills.” However, he mentioned that there is not much reading required in the class. He stressed that if students are listening and taking notes, they shouldn’t have to grab a book to look up the information. “By taking notes I’m helping them connect the dots.”

Mr. Cooper, (Survey 15, Rubric 61), the 11th grade U.S. History teacher, also works hard to help students make connections. And, like Mr. Schwartz, he requires very little reading in his class. “I tend to read with them. It’s like pushing them along on trainer wheels. They’re not readers and it scares me.” There’s no time, he said, to help students develop this skill. “I realize that you’re never going to teach the kid to swim if you’re moving their arms and legs for them, but I don’t have time to let them struggle.”

As students are pushed through the curriculum to meet the demands of the standardized tests, teachers feel the pressure from the administration that all students must succeed. “When things focus on trying to lower the bar so that the ‘D’ and ‘F’ kids can pass at all costs no matter what,” says Mr. Reese, the science teacher (Survey 15, Rubric 51), “it takes the wind out of your sails. You feel unmotivated. You don’t feel energized to go out and tackle things.” Ms. Clyne (Survey 7, Rubric 94), the AP and Honors History teacher, feels the same way. The most frustrating facet about teaching for her is the administrative control that oversees what she does in the classroom. She has difficulty adhering to a double standard imposed by the administration. On the one hand, she says, the administration wants a rigorous academic setting, “holding the line,’ but on the other hand, every child must succeed. She feels that by insuring that no child fails takes away students’ accountability for being responsible for their own actions and deters them from participating in their own learning process.

CHAPTER FIVE: DISCUSSION

The purpose of this study was to determine whether teachers' perceptions of using brain-based strategies were consistent with the strategies they use in the classroom. The study, founded upon Caine et al.'s (2005) 12 brain/mind principles, was conducted in a high school (grades 9-12) in southwest Idaho. The 12 brain/mind principles, divided into three categories—relaxed alertness, orchestrated immersion in complex experience, and active processing of experience, provide a model for brain-based instructional strategies. Each principle, which focuses on one aspect of mental functioning, combines with the others to reflect the interconnectedness of the brain as a living organism. The following discussion includes: the limitations to the study; information drawn from the surveys, observations, and interviews with regard to Caine et al.'s (2005) brain/mind principles; conclusions drawn from the data that could suggest other variables affecting the teachers' ability and/or willingness to use brain-based practices in the classroom; and recommendations for future studies.

Limitations to the Study

Limitations to this study include: only one one-hour classroom observation; the rubric and survey instruments; and a sample size of 18 teachers out of a population of 82 teachers. In this study, there was only one one-hour classroom observation by one evaluator. Multiple observations of the same target teacher may have produced varying data depending on different variables, such as: group dynamics; lesson plans; students' age; students' aptitude; and an elective vs. required class. For example, Mr. Reese believed his instruction was more teacher-directed for the required 9th grade earth science class and more student-centered for the elective 11th/12th grade ecology class. He cited two reasons: students lack discipline in the lower grades, and the earth science class has strict curriculum guidelines tied into the standardized EOC. On the day of the observation in the 9th grade earth science class, students were assigned to enact a repetitive pattern of plotting stars' luminosity and temperature for most of the class period without understanding the implications of the chart's significance. Contrary to this lesson that emphasized rote memorization, are lessons that use a brain-based approach to learning as in the ecology class, where students, according to Mr. Reese, are actively constructing their own learning through investigative study and research.

In addition to variations of instructional approaches based on required versus elective classes, teachers might also use lessons that demonstrate more brain-based strategies, which were not seen the day of the observation. Mr. Story (Survey 19, Rubric 70) who teaches the integrated American Character class, for instance, described a lesson where students picked out a tombstone at the veterans cemetery, and later created a fictional story about the person based on historical events that occurred during that time period. Unlike the lesson that was assessed during the classroom observation that revealed a more teacher-directed approach, this lesson involving the field trip to the cemetery emphasized active processing, one of the categories in Caine et al.'s (2005) 12 brain/mind principles, where students initiate their learning and make deeper connections with the material.

In addition to only observing teachers for one hour in one class, the study was also limited to one evaluator's perspective. Although an inter-rater reliability study showed that the rubric was a reliable instrument for classroom observations, another evaluator could have offered additional insights and perspectives on teachers' behaviors as they applied to brain-based principles.

Regarding the two instruments, the survey and rubric, only the 12 brain/mind principles proposed by Caine et al. (2005) were used to assess the use of brain-based strategies. In addition, specific behaviors were suggested for each of the 12 brain/mind principles that may have restricted teachers' perceptions of what they do in the classroom, as well as to lead teachers to misinterpret specific items. As noted earlier, Ms. Clyne did not acknowledge that she demonstrated any of the behaviors on seven of the twelve principles. This perception revealed inconsistencies with behaviors demonstrated during the classroom observation. For example, she "frequently" demonstrated behaviors relating to four of the seven principles: helping the student understand the concept; helping students see interconnected patterns; allowing students time to apply information; and giving students time to construct their own learning.

Finally, only 18 teachers, 22%, responded to the survey out of a population of 82 teachers. Although the 18 teachers were representative of the larger population in terms of teaching experience, education, gender, age, and ethnicity, having a larger sample of teachers may have produced valuable insights into why teachers perceptions of using brain-based strategies differed from their behaviors demonstrated in the classroom.

Caine et al.'s (2005) 12 Brain/Mind Principles

Data (surveys, rubrics, field notes, interviews, and artifacts) from the sample of 18 teachers, revealed inconsistencies between teachers' perceptions of their use of brain-based teaching strategies with the strategies they demonstrated in the classroom. In order to clarify the data, the following information is arranged by using Caine et al.'s (2005) 12 brain/mind principles, and is divided into the three categories: relaxed alertness; orchestrated immersion in complex experience; and active processing of experience. Themes and patterns derived from the data will then be examined to explore possible extraneous variables that might suggest limitations in teachers' ability and/or willingness to use brain-based practices in the classroom.

Relaxed Alertness

This category refers to a safe environment where students develop self-efficacy by making decisions and choices in order to reach their goals for success. On the survey, the first brain/mind principle in this category addresses how students assess their own learning by self-evaluations, planners, and making goals. Concerning the use of this principle, five teachers claimed "never," twelve claimed "sometimes," and one claimed "frequently." To the contrary, classroom observations revealed little evidence that students assess their own learning. Mr. Clark, the AP Economics teacher, claimed that students frequently do this in his class. But, in fact, only two other teachers had students use evaluative tools to monitor their progress. In Mr. Moore's English class, students used an interactive notebook to keep track of their assignments, and in Ms. Jolly's history class, students used a scoreboard.

The second brain/mind principle emphasizes social interaction as an integral ingredient in cognitive development. On using this principle, none of the teachers claimed "never," five teachers claimed "sometimes," and thirteen teachers claimed "frequently." However, during classroom observations students did not interact with one another in six of the classes, which included: Mr. Moore, Mr. Bixby, and Mr. Durham's English classes; Mr. Simmons economics class; and Mr. Cooper's and Ms. Clyne's History classes.

The third brain/mind principle requires that students have time to process information. This principle refers to allowing students sufficient time to practice and reflect on their learning in order to gain an in-depth understanding. On the survey concerning this principle, four teachers claimed, "never," nine teachers claimed "sometimes," and five teachers claimed "frequently." For the most part, classroom observations revealed a tendency toward direct instruction usually followed by a textbook assignment or worksheet with little opportunity or motive for students to gain deeper insights into their learning.

For example, Mr. Moore, the 9th grade English teacher, indicated on the survey that he "frequently" allows time for students to make connections. However, during the observation, students were allowed very little time to write their reflections and no time to share their view.

Mr. Hobbs, the Spanish teacher, also claimed “frequently” on this item on the survey. Contrary to Mr. Moore, however, Mr. Hobbs does provide students time to process information. For example, students can choose to redeem half of the points missed on their exams by identifying the mistake, making the correction and explaining their answer. He also allows time in class for students to ask questions and work with one another on assignments.

The fourth brain/mind principle emphasizes student choice as a means to engage learning, intrinsic motivation, and self-regulation. Referring to this principle, three teachers claimed that they “never” allow students to pursue their own interests, twelve claimed ‘sometimes,” and three claimed “frequently. During classroom observations, students were seldom observed pursuing areas of personal interest. Teachers directed instruction and discussions. However, in twelve classes, students were allowed to choose to work together or alone on assignments. And in eight classes, teachers said during the interview that students could choose topics for research projects.

Orchestrated Immersion in Complex Experience

The second category, “orchestrated immersion in complex experience,” emphasizes a multi-sensory learning environment that arouses the brain to use its innate resources to seek patterns and solve problems. The first brain/mind principle in this category focuses on providing students a context in order to make connections. On the survey, two teachers claimed that they “never” do this, one teacher claimed “sometimes,” and fifteen claimed “frequently.” During the classroom observations, teachers presented background information, reviewed information, told a story, or asked a question to help students understand the concept before breaking it down into details.

Two teachers who said they never help students understand the context before breaking it down into more details, demonstrated that they do this often throughout the lesson. Ms. Clyne, the Honors History teacher, helped students understand the historical context of the Civil War, and, Ms. James, the mathematics teacher, explained different shapes to her students before having them make calculations.

The second principle, engaging the physiology of the brain, refers to a multi-sensory environment that provides students hands-on experiences, projects, research, discussions, art, music, and movement to build multiple pathways aimed at strengthening the brain's ability to store and recall information. Concerning this item on the survey, none of the teachers claimed "never," eleven teachers claimed "sometimes," and seven teachers claimed "frequently."

Teachers used a variety of sources, such as, graphic organizers, video clips, power point presentations, reading, writing, and problem solving to help students understand concepts. Also, teacher interviews revealed that students use multiple sources when doing research projects, i.e., art, technology, writing, and speech.

However, most of the classroom observations showed that although teachers use different resources to reinforce learning, there was very little input from the student, aside from answering the teacher's questions or completing assignments requiring one correct answer. Learner-centered environments emphasize learning as a process of exploration where the student is challenged to seek patterns and solve problems through logical thinking and creativity.

The third principle, helping students see interconnected patterns, is essential for building an understanding of how ideas relate to each other in a meaningful context. For this item, two teachers claimed “never,” five teachers claimed “sometimes,” and eleven teachers claimed “frequently.” During the classroom observation, teachers frequently used metaphors, analogies, maps, graphic organizers, and relevant examples to help students connect information. Also, teachers used interdisciplinary methods to reinforce concepts. For instance, the economics teachers, Mr. Clark and Mr. Simmons, referred to historical events, politics, and math to help students understand economic concepts concerning regulation of money, and supply and demand.

On the survey, two teachers indicated that they never help students see interconnected patterns. The mathematics teacher, Ms. Mason, mentioned that curriculum requirements restrict opportunities to connect procedures to concepts. During the classroom observation, Ms. Mason used several examples to reinforce the procedure, but made no attempt to connect the idea to a broader context.

Ms. Clyne, the honors history teacher, also claimed “never” on her survey. However, the classroom observation revealed that she frequently helps students make connections. She used art, film, maps, notes, an artifact (the Civil War bullet), and a lecture filled with analogies, metaphors, and stories, to help students understand the events surrounding the Civil War.

The fourth principle concerns teachers' use of multiple forms of assessment, i.e., portfolios, demonstrations, presentations, and exhibits, to assess students' developmental growth. On this item, one teacher claimed "never," and ten teachers claimed "sometimes." Of the seven teachers who claimed "frequently," interviews revealed that most often they use one form of testing, multiple choice tests. Teachers also use students' projects, presentations and essays to assess students' learning.

Active Processing of Experience

The third category, "active processing of experience," promotes curriculum that facilitates the growing and connecting of students' brain structures for more efficient processing. In this category, instruction moves beyond merely memorizing facts, to allowing students time to construct personal connections and meaning to apply to real life situations.

The first brain/mind principle in this category emphasizes the importance of providing students opportunities to consolidate and apply information. Concerning this statement, three teachers claimed "never,' eight teachers claimed "sometimes," and seven teachers claimed "frequently." Six of the teachers' responses showed inconsistencies with responses given earlier on the survey regarding the item in the relaxed alertness category that states, "students have time to process information" in order to make deeper connections.

Ms. James, the mathematics teacher, for example, claimed that she never allows time for students to process information, but sometimes allows time for students to apply learning. During the classroom observation, students were given time to gain deeper understandings as they worked together in groups calculating the lateral area of shapes and explaining their findings to the other members.

Another instance was Mr. Clark, the AP Economics teacher, who claimed that he “sometimes” allows students time to process information, but that he “frequently” allows students time to consolidate and apply information. During the observation, students applied the information that Mr. Clark reviewed in the lecture by creating economic graphs relating to real life scenarios. However, contrary to his commitment of offering students time to apply and consolidate learning, is his view regarding simulated, hands-on activities, like the Economic Summit. In his opinion, the Economic Summit, where students participate in a simulated international trade event, is a waste of time for AP students given that AP economics is only one semester and students need time to prepare for the AP exam.

The next principle relates to capturing and sustaining students’ focus. On the survey, none of the teachers claimed “never,” six teachers claimed “sometimes,” and twelve teachers claimed “frequently.” During the classroom observation, teachers began with the lesson objective to direct students’ focus. To sustain focus, teachers used relevant examples throughout the lesson to help students make connections. However, students’ interest and attention appeared to wane when the teacher dominated the instruction with little input from the students.

For example, in Mr. Cooper’s 11th grade U.S. History class, he claimed that he “frequently” uses strategies to sustain students’ interests. And, during the observation, it was evident that he did use a variety of strategies, i.e., humor, relevant examples, analogies, maps, graphs, video clips and a textbook assignment to reinforce learning. However, the lesson plan did not provide opportunities for student interaction, which Mr. Cooper attributes to time limitations preparing students for the EOC exams.

The third principle focuses on the student's ability to construct their own learning with the guidance of teachers. Behaviors include writing in journals, getting feedback, asking questions, solving problems, making predictions, and doing research. On this principle, one teacher claimed "never," fourteen teachers claimed "sometimes," and three teachers claimed "frequently." During the observations, it was noted that the most commonly used strategy was feedback as teachers answered questions and interacted with students as they worked on assignments.

In the interviews, teachers claimed they use research projects, presentations and simulations as well to help students get involved in their own learning experiences. Mr. Farley, for example, noted that in the wildlife class, students have opportunities to construct their own learning through field observations. And, in Mr. Reese's Ecology class, students investigated global warming and wrote a position paper.

The fourth principle recognizes that students learn more effectively when teachers address more than one learning style by incorporating other methods to address the multiple intelligences. For example, teachers could use art and music, show a video clip, pass around artifacts or have the students build something tangible.

Concerning this principle, one teacher claimed "never," six teachers claimed "sometimes," and eleven teachers claimed "frequently." During the observations, teachers used various methods to address individual learning styles: visual (graphic organizers, video clips, power point presentations, reading); auditory (discussion and lecture); and tactile (note-taking and written assignments).

Other Variables

Of the 18 teachers who participated in the study, the discrepancy in scores was inconclusive in regards to the teacher's age, years of experience, or certification, which also includes national board certification. For example, the history teacher, Mr. Story (Survey 20, Rubric 70) and the English teacher, Mr. Durham (Survey 12, Rubric 55) who both teach the American Character class, have national board certification. Yet, Mr. Durham's perceptions of using brain-based strategies were more consistent with his behaviors than Mr. Story's perceptions and behaviors. (The average scores on the survey and rubric were 16 and 72 respectively.) Also, there was no evidence to suggest that students' characteristics, i.e., gender, age, or aptitude was a factor in explaining teachers' inconsistencies with perceptions and behaviors. For example, among the six teachers profiled in this chapter, Ms. Clyne, who scored the highest on the classroom rubric and lowest on the survey, was the only teacher who had AP and honors students. However, among the 18 teachers in the study, Mr. Clark, the AP economics teacher, (Survey 19, Rubric 100), and Ms. Vincent, the 9th grade Honors Earth Science teacher, (Survey 16, Rubric 77) didn't show this pattern of inconsistency.

There was, however, data to support the existence of other variables affecting teachers' perceptions and behaviors. Evidence from the study suggests that teachers' gender may be a consideration in determining the discrepancy in scores. Of the 18 teachers in the study, only seven were female. And, yet, there were a disproportionate percentage of female teachers comprising half of the most disparate scores. One female teacher, Ms. Jolly, (Survey 21, Rubric 45) overestimated her perception of using brain/based principles, and Ms.Clyne (Survey 7, Rubric 94) and Ms. James (Survey 11, Rubric 89) underestimated their use of brain/based strategies in the classroom.

In addition to gender, subject matter, as in the case of the two mathematics teachers, Ms. Mason (Survey 14, Rubric 82), and Ms. James, may suggest a pattern in determining disparate scores. Although Ms. Mason's score wasn't one of the most disparate, it still revealed that, like Ms. James, she underestimated her use of brain-based strategies in the classroom. Although, both teachers acknowledged that they "frequently" use student collaboration, which was evident during the observation, they revealed inconsistencies with perceptions regarding students' construction of learning and time to process. As noted with Ms. James, she indicated that students "never' have time to process and apply learning, and Ms. Mason indicated "sometimes." However, the classroom observation showed that the two math teachers engaged students' learning "frequently" through problem-solving, discussion, and feedback, as well as a hands-on activity in Ms. James' class where students were tasked to figure out the areas to shapes and explain their findings to their peers.

Also, inconsistent on the teachers' surveys were their perceptions regarding two other principles. On the first principle in the "orchestrated immersion in complex experience" category, Ms. Mason indicated that she "frequently" helps students understand the concept before breaking it into parts. Ms. James indicated that she "never" does it, yet both teachers demonstrated this behavior "frequently" throughout the observation each time they introduced a math concept. Regarding the other principle in the third category, "active processing of experience," it states that teachers help students see interconnected patterns. Ms. Mason indicated "never," and Ms. James stated "sometimes." In fact, in both math classes, students were continuously connecting patterns to find solutions to problems. Both teachers facilitated this effort "frequently" throughout the lesson as they monitored students' progress and answered their questions.

Although, this data suggests a pattern with the two mathematics teachers of inconsistency between their perceptions and behaviors, it may not be indicative of how the other 10 math teachers at the school perceive themselves and their use of brain-based strategies. For instance, in the other departments reflected in this study, which included world language, English, social studies, and science, there were no patterns to suggest that subject matter correlated with teachers' misperceptions of using brain-based strategies. In the English department, for example, Mr. Moore's scores on the survey and rubric (Survey 22, Rubric 48), did not correlate with the other two English teachers' scores, Mr. Bixby (Survey 13, Rubric 68), and Mr. Durham (Survey 12, Rubric 55), who were more consistent with their perceptions and behaviors.

Teachers' interviews also revealed other variables that could affect inconsistencies with teachers' perceptions and behaviors, particularly in regards to preparing students to pass the EOC exams. Teachers who instruct multiple disciplines, age groups, or elective courses that are not restricted by a standardized district EOC exam, claimed to show variations in teaching styles and use of brain-based strategies as in the case of the science teacher, Mr. Reese, who teaches a required 9th grade science class driven by an EOC, and an elective ecology class.

In addition to variations of instructional approaches based on required versus elective classes, teachers also could implement lessons that demonstrate more brain-based strategies, which were not seen the day of the observation. And, as already mentioned, one other variable that might explain inconsistencies of teachers' perceptions with observable behavior could be teachers' misunderstandings of brain-based principles and their implementation in the classroom.

Summary

Two themes emerged from the data suggesting possible limitations affecting teachers' perceptions of using brain-based strategies with behaviors demonstrated in the classroom. The two themes were time constraints and student apathy. Concerning the first issue, teachers discussed how time constraints in covering the curriculum and preparing students for standardized EOC exams conflicted with helping students apply learning and make deeper connections. Because of the pressure to teach to the test, teachers felt that they are just skimming the surface of student learning.

As pointed out in the literature review in this study, limiting a student's experience to specific skills and predicted outcomes, ignores the complexity of the brain and its natural ability to seek meaning through pattern-making and problem-solving. Acknowledging the brain's capacity to activate several different functions simultaneously, embraces the notion that learning and development are messy and nonlinear (Hung, 2003). Immersing the multiple capacities of the brain so that they support and reinforce each other, requires a learning environment that stimulates and strengthens neural connections through many sensory, cultural, and problem layers more closely related to the real world (Hung, 2003). Through a process of exploration incorporating activities that engage the whole brain (i.e., discussion, writing, drawing, poetry, movement, music, simulations, and visual arts), a student changes and modifies what he already knows to gain knowledge and form new and higher level neural structures that grow from or connect to structures already there (Bransford et al., 2000). However, when robbed of the opportunities to explore and construct their own learning, students' abilities to think and understand are seriously impaired (Dewey, 1933). By ignoring the students' experiences and homogenizing education into neatly controlled portions, students become passive consumers repeating memorized information, while no longer participating in the construction of their own understandings (Freire, 1970).

Concerning the second issue, student apathy, teachers lamented that students are becoming less involved in their learning and are looking for immediate answers with minimal effort to achieve success. In such an environment, where the product is more revered than the process, students are less motivated to initiate and construct their own learning. Caine et. al. (2005) contends that when students feel comfortable with their own learning and learning environment, they are more apt to recognize that learning is an ever-evolving process that takes time, includes trial and error, and builds upon success. It's the process of learning, not the final solution, that strengthens and increases synaptic growth (Jensen, 1998). However, students programmed to enact specific behavior patterns, are less likely to step beyond their comfort zones to take risks in learning as evidenced in this study. Teachers expressed frustration and concern regarding students' apathy and unwillingness to challenge themselves in order to learn from their own mistakes.

The brain/mind principles advocate an environment that allows time for students to have many opportunities to practice, and correct mistakes to gain expertise and in-depth understandings. Meaning is generated from within, not externally, so too much external stimuli inhibits the brain's ability to process (Wolfe, 2001). This finding suggests that students have several minutes to reflect on new learning, such as, writing in journals or discussion in small groups (Wolfe, 2001; Jensen, 1998; Smilkstein, 2003). Students need time to process information in order to reshape their thinking and change entrenched patterns in the brain (Caine et al., 2005). However, according to Darling-Hammond (1997), students are not allowed enough time in school to deal with anything in depth because the curriculum is too overwhelming.

In this study, teachers felt pressured with time constraints and curriculum demands, to adhere to the administrations' standards of implementing rigor, but at the same time insuring that each student will succeed. Teachers, like the English teacher, Mr. Bixby, resort to pushing students through because the students won't push themselves. In addition, teachers don't have the time to teach basic skills like reading and writing because as the history teacher, Mr. Cooper, pointed out, "I don't have time to let them struggle."

Without the support from the school, district and/or state to enforce a curriculum that allows students time to make deeper connections, teachers will continue to skim the surface of student learning. As stated earlier in this study, Smilkstein (2003) maintains that human beings' innate learning process is stifled by "dumbing down" curriculum to a prescribed set of guidelines and expected outcomes. Thus, it isn't surprising that a rigid curriculum promotes apathetic and ineffectual students who are uninterested and/or unable to initiate and construct their own learning. However, if students are given an opportunity to experience activities and environments that are compatible with the brain's natural learning process to be critical and creative thinkers, they can learn naturally, successfully and with motivation.

Suggestions for Future Studies

In order to better prepare students to be self-governing, independent thinkers for the 21st century, Caine et al. (1999) emphasizes a major shift in teachers' and administrators' thinking about education. Rather than viewing school as a delivery model of facts and information, Caine maintains that school be seen as a model based on meaningful learning acquired through guided experience. In this environment, teachers facilitate learning by empowering students to take responsibility in establishing learning goals, monitoring their learning, keeping records, and making choices.

In this study, teachers shared a vision of teaching and learning that embraced an understanding that students learn better when they are actively involved in the learning process. But, "teaching to the test' conflicted with allowing students time to process and make deeper connections. Changes to the structure of school are necessary if students are to be honored as the primary focus in the educational process.

Further studies could contribute valuable insights that may influence and alter traditional structures of schools. These studies could include: investigating variables in a high school that may enhance or limit brain-based instruction, i.e., block schedule, class size, specific disciplines, student's age or gender, and student's aptitude; comparing a "student-centered' school that implements brain-based instructional practices with a traditional school, and determine its impact on learning and standardized test scores; and compare hands-on interventions, i.e., math navigator, with traditional teacher-directed practices, and determine the impact of these interventions on learning and standardized test scores

In addition, because this study only addressed teachers' perceptions and behaviors regarding brain-based instruction, studies could examine other stakeholders in the educational community. For example, interviews with principals could enhance understandings of their leadership style and knowledge of brain-based educational tenets. And, district administrators, and state and federal policy makers, could also provide insights regarding brain-based instructional practices and its utility in schools.

Understanding brain research and its implications for the classroom is important to guide pedagogy. By creating a brain-based curriculum, teachers are encouraged to think in terms of brain-based instruction and helping students understand how their brains learn. By providing students a user's guide to their brain, teachers empower students to know what to do and how to do it to become successful learners (Smilkstein, 2003).

Developing partnerships with universities to share knowledge and instructional practices could facilitate teachers' and students' efforts in understanding how the brain functions. Pre-service and in-service teachers, as well as administrators, could also benefit from university courses on brain-based teaching. Providing professional support in helping teachers understand the brain and how students learn, will guide instructional practices that liberate students to seek the power within themselves and the world beyond.

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APPENDIX A

Classroom Rubric

Classroom Rubric

The following rubric will be used as a checklist to identify Caine et al's (2005) 12 brain/mind principles in the classroom.

Relaxed Alertness **Score:**
An environment that consists of low threat and high challenge.
1. Do students assess their own learning? (self evaluations, planners, goals)
2. Do students interact with one another? (projects, small groups, partners,)
3.Do students have time to process information? (journals, discussion, summaries, paraphrase)
4 Do students pursue their own interests? (projects, books, research)
Orchestrated Immersion in Complex Experience **Score:**
An environment that offers multiple experiences that challenge and
interest learners.
1. Does the teacher help students understand the concept before breaking
it into parts.(i.e., use stories, presentations, simulations, video).
2. Does the teacher provide students a multi-sensory environment? (i.e. drama,
computers, hands-on experiences, writing, field trips, music, movement, art, speech)
3. Does the teacher help students see interconnected patterns?
(i.e., discussion, interdisciplinary, arts, projects, metaphors, analogies)
4. Are there multiple forms of assessment? (i.e., portfolios,
demonstrations, presentations, exhibits, art)
Active Processing of Experience **Score:**
An environment that encourages adaptive decision making and critical thinking skills within a real-life context.
1. Do students have opportunities to consolidate and apply information?
(i.e., writing in journals, discussion groups, paraphrasing, summarizing)
2. Does the teacher have the students' attention? (i.e., novelty, emotion,
meaning, humor, relevancy, lesson objective, games)
3. Do students have opportunities to construct their own learning?
inquiry, problem solving, journaling, feedback, predictions, debates, research)
4. Does the teacher address more than one learning style? (i.e. visual, auditory, kinesthetic)

APPENDIX B

Teacher Survey

Name________________________________

The purpose of this study is to explore educational practices in secondary classrooms. Completion of the survey implies consent to be interviewed and observed, however, you retain the right to withdraw from the study at any time without consequence. Information regarding age, gender educational certification and years of experience will be used unless you opt to exclude it.

	Never	Sometimes	Frequently
Students assess their own learning (i.e., self evaluations, planners, goals)			
Students interact with one another (i.e. projects, small groups, partners)			
Students have time to process information (i.e., journals, discussion summaries, paraphrase)			
Students pursue interests (i.e., projects, books, research)			
Help students understand the concept before breaking into parts (i.e. use stories, presentations, simulations, videos)			
Provide students a multi-sensory environment (i.e. computers, hands-on experiences, writing, field trips, drama, music, art, movement, speech,			
Help students see interconnected patterns (i.e., discussions, interdisciplinary, arts, projects, metaphors, analogies)			
Use multiple forms of assessment (i.e. portfolios, demonstrations, presentations, exhibits, essay, art)			
Students have opportunities to consolidate and apply information (i.e. writing in journals, small discussion groups, paraphrasing, summarizing, projects)			
Have the students' attention. (i.e., use, novelty, emotion, meaning, humor relevancy, lesson objective, games)			
Students have opportunities to construct their own learning (i.e., problem solving, journaling, research, feedback, student-generated questions, debate)			
Teacher addresses more than one learning style (i.e. visual, auditory, kinesthetic)			

APPENDIX C

Interview Guide

Interview Guide

1. How many years have you taught school? Name your degrees and certificates?

2. Where do the ideas for your teaching come from?

3. How do you help students process information? (journals, discussions, projects)

4. How do you help students understand the context—the “big picture?” (integrate subjects, use relevant examples)

5. How do you accommodate students’ interests or needs?

6. Extension question may be asked based on questions about or on something observed in the classroom.

APPENDIX D

Teacher Descriptors (82 Certified Teachers)

Teacher Descriptors (82 Certified Teachers)

Department	**Math**	**Lang. Arts**	**Science**	**Arts**	**World Lang.**	**Voc. Ed.**	**PE**	**Sp. Ed.**	**Social Studies**
Number of Teachers	**12**	**13**	**11**	**10**	**8**	**4**	**6**	**6**	**12**
Years of Teaching									
Less than 1		2	1	1	1	3			
1-10	6	4	4	5	2		3	6	2
11-20	4	5	5	3	3		2		5
21-30	1	1	1	1	2		1		2
More than 30	1	1				1			3
Certification									
Bachelors	8	10	8	10	7	3	6	6	10
Masters	4	3	3		1	1			2
Doctoral									
National Board Certification		1							1
Gender									
Female	7	7	7	5	5	2	3	2	4
Male	5	6	4	5	3	2	3	4	8
Age									
22-29	1	2		4	1		1	1	
30-39	6	2	9	1	3	2	2	2	1
40-49	2	5	2	2			2	3	5
50-59	1	2		3	4	1	1		5
60 or over	2	2				1			1
Ethnicity									
Caucasian	11	12	11	9	8	4	6	6	12
African American		1							
Hispanic	1								
Asian				1					

APPENDIX E

Consent to be a Research Participant

CONSENT TO BE A RESEARCH PARTICIPANT

BOISE STATE UNIVERSITY

A. PURPOSE AND BACKGROUND

I'm conducting a study to explore instructional practices in secondary education classes. The purpose of the study is to determine if teachers' perceptions of their use of teaching strategies are consistent with the strategies they use in the classroom.

B. PROCEDURES

If you agree to be in the study, the following will occur:

1. You will fill out a 12-item self-assessment survey. On each statement you will check the appropriate box indicating how often this strategy is used in your classroom.

2. You will allow me to observe a one-hour class session where I will use a rubric (aligned with the survey) and field notes to record the strategies.

3. I will arrange with you a 20-30 minute interview within two days after the observation that can be conducted in your classroom or mine.

C. RISKS/DISCOMFORTS

For this research project, the researcher is requesting demographic information which includes: age; gender; educational certification; and years of experience. Due to the make-up of Idaho's population, the combined answers to these questions may make an individual person identifiable. The researchers will make every effort to protect your confidentiality. However, you are not required to answer any of the questions that may make you uncomfortable.

D. BENEFITS

There will be no direct benefit to you from participating in this study. However, the information that you provide may enhance teachers' and administrator's understandings of instructional practices and how these practices are currently being implemented.

E. COSTS

There will be no costs to you as a result of taking part in this study, other than the time spent to participate.

G. QUESTIONS

If you have any questions or concerns about participation in this study, you should first talk with the investigator. If for some reason you do not wish to do this, you may contact the Institutional Review Board, which is concerned with the protection of volunteers in research projects. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

H. CONSENT

You will be given a copy of this consent form to keep.

PARTICIPATION IN RESEARCH IS VOLUNTARY. You are free to decline to be in this study, or to withdraw from it at any point.

I give my consent to participate in this study:

___________________________________ __________________

Signature of Study Participant Date

I give my consent to be audio taped in this study:

___________________________________ __________________

Signature of Study Participant Date

___________________________________ __________________

Signature of Person Obtaining Consent Date

THE BOISE STATE UNIVERSITY INTSTITUTIONAL REVIEW BOARD HAS REVIEWED THIS PROJECT FOR THE PROTECTION OF HUMAN PARTICPANTS IN RE

APPENDIX F

Consent Letter

March 4, 2009

Dear Darcy Jack,

I grant you permission to conduct a research study at Eagle High School this Spring 2009 (March through May) that will explore instructional practices in secondary education classes. I understand that faculty members will volunteer for the study and data will include surveys, classroom observations and interviews.

Sincerely,

Terry Beck
Eagle High School Principal

APPENDIX G

Faculty Surveys/Rubrics

Faculty Surveys/Rubrics

Departments/ teachers	Subject	Score for Survey	Score for Rubric	Years Teaching	Degree
Math					
Ms. Mason	alg. 1/math analysis	14	82	17	BA
Ms. James	conceptual/geometry	11	89	3	MA
English					
Mr. Moore	9th Eng.	22	48	7	BA
Mr. Bixby	11th Eng.	13	68	33	BA
Mr. Durham	11th Am. Character	12	55	25	MA, NB
Social Studies					
Ms. Clyne	10th honors history 11th AP history	7	94	30	BA
Ms. Jolly	10th history	21	45	11	BA
Mr. Cooper	11th history.	15	61	11	BA
Mr. Schwartz	11th history	15	60	16	BA
Mr. Story	11th Am. Character	20	70	28	MA, NB
Mr. Simmons	12th econ.	16	90	15	MA
Mr. Clark	12th AP econ	19	100	7	BA
World Language					
Mr. Hobbs	Spanish	19	72	5	BA
Ms. Tripp	French	19	72	25	MA
Ms. Jewel	Latin	15	86	10	BA
Science					
Ms. Vincent	9th honors earth	16	77	24	MA
Mr. Reese	9th earth	15	51	3	BA
Mr. Farley	12th wildlife/ anatomy	21	66	9	BA